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CONTENTS

THE COVER: The gleaming rectangular pattern formed by rows of modern crossbar switches characterizes many present-day central offices. Here, these switches intersect banks of the newly developed wire-spring relays at a central office in Cumberland, Maryland. (See page 188.)

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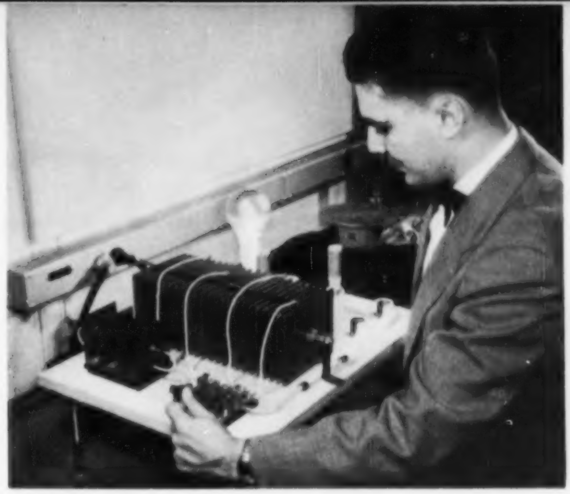
Silicon Power Diode Development



M. B. PRINCE *Solid State Device Development*

Considerable attention has been given recently to the increased use of silicon in semiconducting devices such as various types of transistors and the Bell Solar Battery. The semiconducting properties of silicon are also being profitably used in another less widely known application. A series of diodes for power rectification and numerous other purposes has been developed using silicon as the basic element. The electrical and thermal properties of these devices, as well as their small size, make them ideally suited to a number of applications throughout the Bell System.

During the past two years the silicon photovoltaic converter commonly known as the Bell Solar Battery* has been receiving wide public attention. This battery is one member of a class of devices made possible by the diffusion process for introducing impurities into silicon to create a p-n junction. To derive reasonably useful amounts of power from silicon photovoltaic cells, it is necessary to use relatively large amounts of expensive single-crystal silicon. Until the cost of this silicon is reduced considerably, the use of these cells will be very limited.

* Record, *July*, 1955, *page* 241.

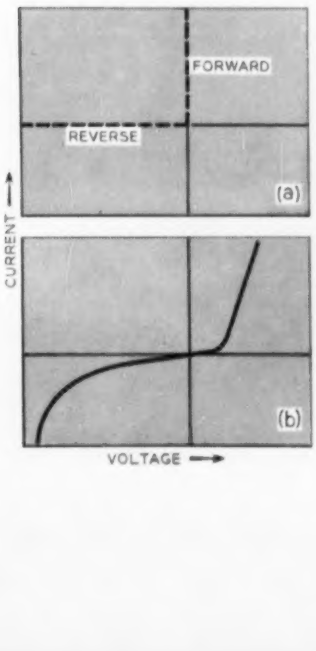


Fig. 1 (a) — Ideal rectifier current voltage characteristic. (b) — Semiconductor rectifier current voltage characteristic.

However, the same development that has produced the silicon photovoltaic cell has also brought forth the silicon power diode. The latest silicon power diodes, which use small amounts of single-crystal silicon, show great versatility in the electrical engineering field. The cost of the silicon used when these devices are made in large numbers will be but a couple of cents per diode even at the present market price of the pure silicon. The electrical properties of these diodes make them probably the best silicon power rectifiers produced to date. Several applications of these diodes other than as power rectifiers make use of the excellent forward and reverse current-voltage characteristics of the diffused junction. The thermal properties of silicon make possible the use of these diodes at temperatures higher than rectifiers made from copper oxide, selenium or germanium can withstand in operation.

Figure 1(a) shows what an engineer would like in the way of an ideal rectifier. It will pass a large amount of current in the forward direction without any voltage drop, and will pass no current for any applied voltage in the reverse direction. At present, no device with this characteristic exists. A typical

semiconductor rectifier has a characteristic of the type shown in Figure 1(b).

To have an efficient rectifier, it is necessary to keep the series resistance as low as possible. This resistance consists of two parts: the silicon body resistance, and the contact resistance. The diffusion technique that has been applied and the present method of making contacts to the devices result in suitably low series resistances.

Silicon diodes are made with p-type silicon wafers. In this process, phosphorus is diffused into one side of the wafer to create a p-n junction and boron is diffused into the opposite side to permit a low resistance contact to be made. The relatively high concentration of phosphorus near the surface of the silicon wafer results in a region that is referred to as n^+ to differentiate it from the n region result-

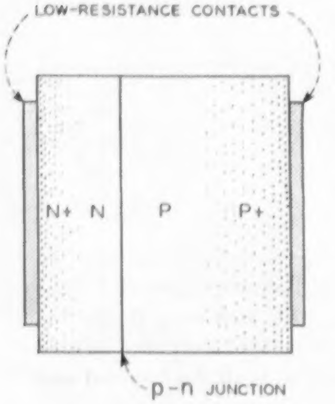


Fig. 2 — Configuration of a diffused silicon rectifier wafer which reduces the effective body resistance to negligible values.

ing from the lower concentration of the phosphorus impurity deeper in the wafer. In a similar manner, the diffusion of boron results in the formation of p and p^+ regions in the wafer. The resulting configuration of the wafer is shown in Figure 2. This configuration reduces the effective body resistance of the silicon to negligible values.

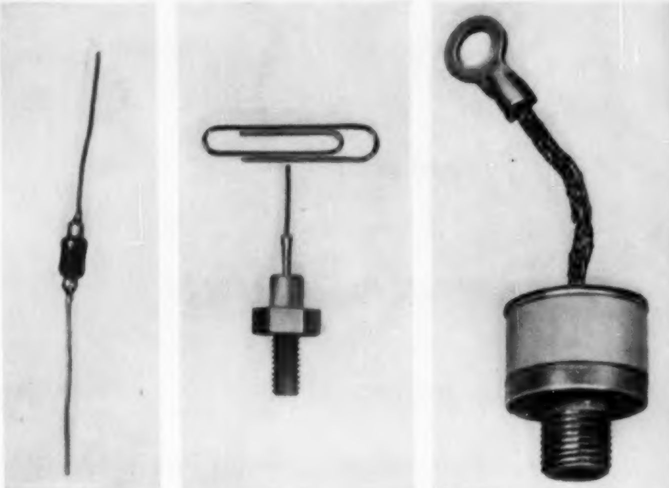


Fig. 3 — Developmental silicon rectifiers. Left, 0 to 1 ampere; center, 1 to 10 amperes; and right 10-100 amperes.

Lowering of the silicon body resistance can be roughly described as follows: When the diode has a forward voltage impressed upon it, electrons from the heavily doped n^+ region are injected into the p region. If the lifetime for these electrons in the p region is long enough, they will diffuse across the p region and reach the p^+ region with little recombination. To maintain electrical neutrality, holes are injected into the p layer from the p^+ region. These extra mobile carriers, both electrons and holes, reduce the resistance of the silicon body. The higher the current density, the higher are the injected mobile carrier densities and, therefore, the lower is the effective resistance. When a reverse voltage is applied to the diode, a normal reverse characteristic is obtained.

The entire silicon wafer, which may be as large as one inch in diameter, is nickel plated to make it possible to solder leads to the resulting diodes. It is then necessary to decide what kind of diode is wanted

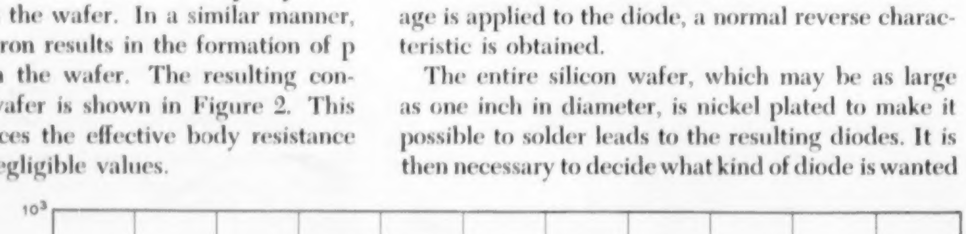


Fig. 4 — Typical current-voltage characteristics of developmental rectifiers.

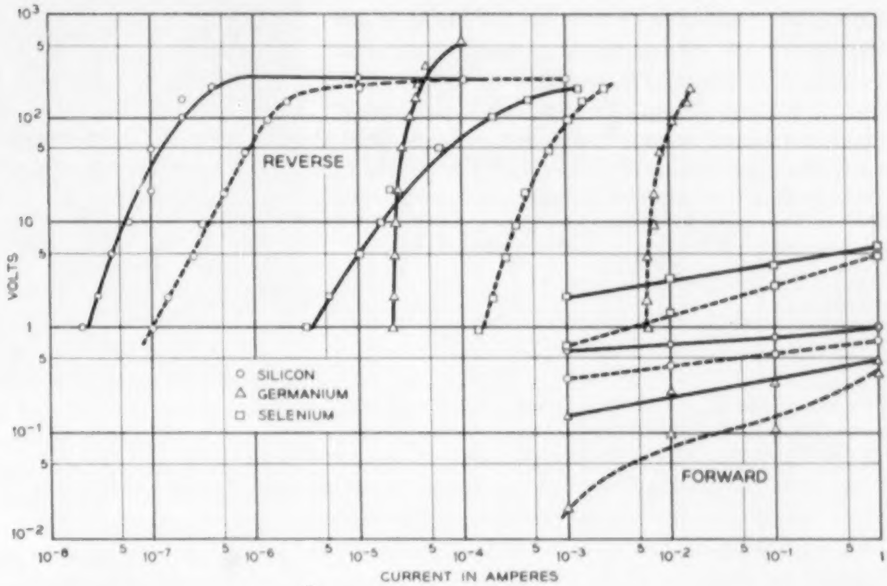


Fig. 5 — Comparison of the characteristics of silicon, germanium, and selenium rectifiers operated at 25°C (solid lines) and at 125°C (broken lines).

and dice of the appropriate size are cut from the wafer. Three developmental silicon power diodes are shown in Figure 3. The dc ratings of these units used as rectifiers range up to 100 amperes, as given in the figure. The peak inverse voltage is greater than 200 volts. The current-voltage characteristics of typical units of the three developmental models are shown in Figure 4 on logarithmic scales. These data were obtained at room temperature.

One of the advantages to be gained by using silicon rather than some other semiconductor in device fabrication is that silicon units can operate at temperatures up to 200°C. This advantage can be seen in Fig. 5 where a silicon developmental unit is compared with the commercially available germanium unit and a six-element selenium rectifier stack rated at 100 milliamperes. Curves of the forward and reverse characteristics at 25°C indicated by solid lines, and similar curves taken at 125°C indicated by broken lines are given in Figure 5. The forward characteristic is best for the germanium device at all temperatures and the reverse currents are least for the silicon rectifier. The selenium rectifier is a poor third in the forward direction. However, if one has to operate the device at 125°C only the silicon rectifier will be satisfactory in both the forward and reverse directions.

It has been found that the silicon power diodes dissipate about one watt per ampere of rectified current. The packages of the units shown in Figure 3

Fig. 6 — R. C. Swenson tests silicon rectifiers. Typical characteristic appears on the oscilloscope.

Fig. 7 — R. L. Rulison examines silicon wafers that are used in fabricating rectifiers.

can readily dissipate only ½, 1 and 3 watts of power respectively. To operate these diodes at their maximum current rating it is necessary to supply some type of cooling system. The simplest system is an attached convection-cooling fin. It has been determined that a copper convection-cooling fin is able to dissipate 8 milliwatts per square inch per degree

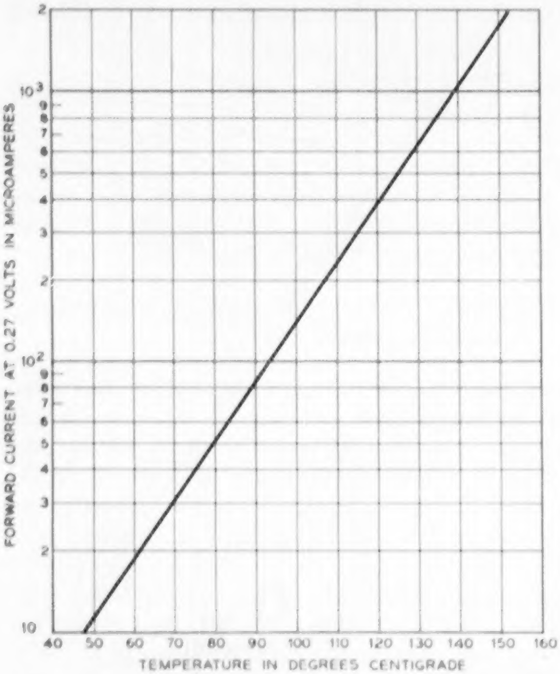


Fig. 8 — Semi-logarithmic plot of forward current versus temperature at fixed voltage.

centigrade. This cooling rate is obtained from the difference between the average temperature of the fin and the ambient temperature over the effective exposed area of the fin. For example, a copper fin 3½ inches square when mounted so that both the surfaces are effective for cooling will be able to dissipate 10 watts, and at the same time prevent the temperature of the fin from exceeding 50°C above the ambient temperature.

It is possible that most of these power diodes will be used in applications other than as power rectifiers. Voltage reference, pulse clipping, and modulator applications depend upon the sharp rise in the forward characteristic of the diode which has a sharp bend close to 0.6 volt in all the devices.

These power diodes may also be used as control elements in many ways. One method, for example, makes use of the fact that the small-signal ac resistance of these devices varies rapidly with the forward dc current through the diode. A sensitive temperature control can be obtained by using the direct current at a constant small forward voltage as the control signal. As shown in Figure 8, a plot of the direct current versus temperature for a forward voltage of 0.27 volt, a 2°C change in temperature corresponds to a 10 per cent change in current.

In addition to the uses mentioned, these units can be used in all of the many standard low frequency and carrier frequency diode applications. Diodes of this family can also be treated to make them useful in moderately high frequency switching applications. The present units are capable of operating at the rate of one million cycles per second. It is believed that further development will increase the maximum operating frequency by a factor of ten.

Thus, from the techniques developed for the Bell Solar Battery has come an entire series of silicon diodes which have opened up several new applications for semiconductor devices. Also, these diodes will make it possible to use present circuits under more extreme conditions of temperature and volume.

M. B. Prince received an A.B. degree from Temple University in 1947 and a Ph.D. from Massachusetts Institute of Technology in 1951. He joined the staff of Bell Telephone Laboratories in 1951 where he has been concerned with the physical properties of semiconductors and semiconducting devices. During the past two years he has been associated with the development of silicon devices, including the Bell Solar Battery and silicon power rectifiers. Dr. Prince is a member of the Institute of Radio Engineers, American Physical Society, and Sigma Xi.

Automatic "Answer Only" Set

C. M. TARIS *Facilities Development*

A series of automatic answering devices is one of the recent developments in the Laboratories' continuing program to provide better and more useful service to telephone customers. The newest of these machines is an "answer only" device designed to play a recorded message in response to an incoming call on an unattended telephone. In addition to use by a variety of telephone customers, "answer only" devices are being employed in a number of places within the telephone plant itself.

For the past few years, the operating telephone companies have been offering automatic telephone answering service to telephone customers for a moderate monthly charge. This service is provided by a device that is installed on the customer's premises and is connected to his telephone line. It automatically answers any incoming call to an unattended telephone with the customer's pre-recorded announcement, and then records the caller's response. The recorded incoming messages are available for immediate playback upon the customer's return.

The telephone answering service was begun, on a trial basis, with the F-50070 Teletranscriber. These trials resulted in the design of the 1A telephone answering set.* Since then, the 1A set has undergone several modifications to make it conform more closely to the current needs of the users as brought to light by the continuing experience in the field. The Western Electric Company is now engaged in production of the 1BA telephone answering set which is the present version of the basic 1-type "answer and record" set.

Customer surveys have indicated a need for a simplified automatic telephone answering service or, as it has come to be called, an "answer only" service. A machine designed specifically for this use answers a call automatically with an announcement, pre-recorded by the customer, that does not solicit a "left message" response from the caller. The machine, therefore, need not have facilities for recording messages from the telephone line.

A neighborhood theatre, for example, could make good use of "answer only" service. The recorded announcement would recite the day's program and the starting times of the feature film. Not only would the answering set remove a burden from the cashier or the manager during rush hours but it would also supply the information when the theatre is closed.

Moreover, there are uses for an "answer only" machine within the Bell System plant itself. In one current application, it serves as an automatic intercept device in an unattended community dial office. The machine is automatically cut in when a calling customer dials a non-working number. The pre-recorded announcement tells the caller that he has reached a non-working number, and advises him to consult the directory or to call an operator if assistance is needed.

Many users of "answer and record" machines also have an occasional need for the supplemental "answer only" service. Late model sets were therefore designed to provide the customer with the option of "answer and record" or "answer only" operation. The demand for "answer only" service exclusively was great enough, however, to justify the development of a machine designed specifically for this purpose. The 2A telephone answering set (see headpiece), designed by the Laboratories and now in

* RECORD, *November*, 1953, *page* 439.

production by Western Electric, is the resulting automatic "answer only" set. It is small, comparatively simple, and economical to manufacture.

For the sake of standardization, the 2A set's basic design followed, insofar as possible, that of its predecessors: the 1A, 1AA and 1B telephone answering sets. For ease of maintenance, early availability and economy, many mechanical and electrical parts are common and interchangeable. The design also provided for anticipated special applications. In addition to the facilities that enable it to perform its principal functions, "answer only" and "community dial office intercept" service, other facilities are included that give the 2A set special operational features. These provide for the recording of a new announcement from a remote location, operating the machine in conjunction with key-telephone systems and controlling a special supplementary recorder. The last named would be used for the recording of incoming messages in special installations where a 1-type set would not be suitable. At present, external facilities are not available, however, to implement for the "remote-record" and supplementary recorder control features.

In a typical installation, a customer's telephone set and telephone line are connected to the 2A telephone answering set. The telephone is used to dictate and check the announcement that the customer wishes callers to hear. The set's power-cord plugs into any convenient 110-volt ac outlet. In dc areas, a vibrator-inverter, designed especially for the answering sets, may be used. The operating power consumption is 70 watts; the stand-by power drain (while the machine is waiting to answer a call) is practically negligible — less than 5 watts. This represents the power required to light two front panel indicator lamps.

The photograph at the head of this article shows the "answer only" set and its front panel controls: the on-off switch, the "function" switch and the operate button. A dictate light, a "ready" light and an illuminated Bell System medallion are also mounted on the front panel. When the on-off switch is turned to the "off" position, ac power is disconnected and the customer's telephone set is connected directly to his telephone line. The telephone can then be used in the normal manner, without regard for the answering set. When this switch is turned to the "on" position, a lamp behind the Bell System medallion lights to indicate that power is applied to the 2A set, and that the telephone set is connected to its internal mechanism as shown in Fig. 1. The machine is now ready for immediate use either for recording an announcement by the telephone customer or answering an incoming call.

The switch at the upper left of the front panel in the headpiece bearing the three operational designations is used to choose the function to be performed by the 2A set. The ANNOUNCEMENT-DICTATE function, as the name applies, is used to record an announcement. To do this, the customer turns the knob to the DICTATE position; he depresses the operate ("O") button and holds it down. When the red indicator below the engraved word DICTATE lights up, he talks into the telephone handset. This red dictate light will remain lit during the dictation period and until the recording time limit is approached. At that time it will start to flash to warn the customer that the recording period is nearing an end. As soon as the customer finishes dictating his announcement he releases the "O" button. The machine immediately restores itself to the "ready" condition with no further manual operation.

The customer can listen to his recording by turning the function knob to the ANNOUNCEMENT-CHECK position and again depressing the operate button. The announcement is reproduced through the telephone handset. The reproduce level is attenuated approximately 15 db during the check period to

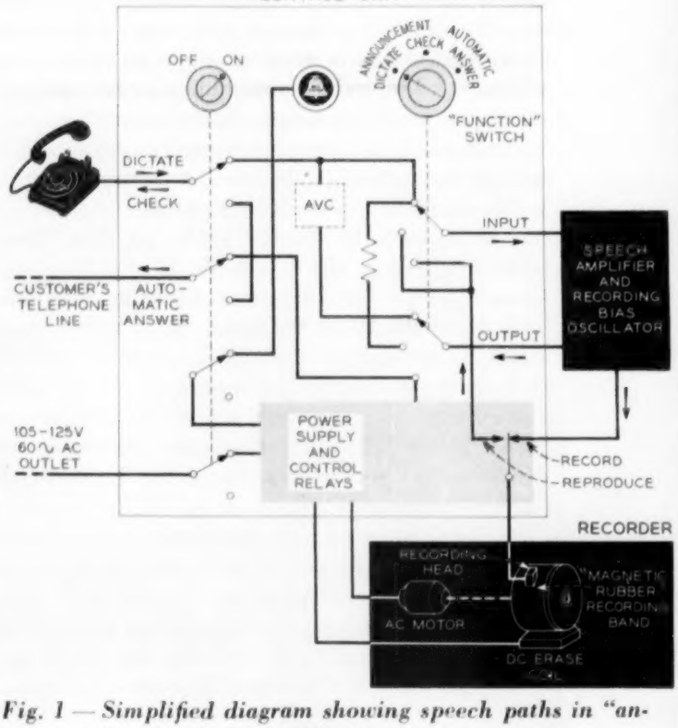


Fig. 1 — Simplified diagram showing speech paths in "answer only" set in the "record" position.

Fig. 2 — J. J. Onder adjusts the magnetic recorder of the "answer only" set. The control unit can be seen in the background, and the amplifier in the lower foreground at the right.

simulate the losses over long telephone connections. This results in a monitoring that encourages dictation at an acceptable announcement level. By requiring the user to depress and hold down the operate button, the latter is made to perform the combined functions of a start and stop button. Not only are economy and simplicity achieved, but also an important operational feature whereby the end of an announcement of any duration between 5 and 60 seconds is unconsciously and automatically made to coincide with the disconnect of the 2A set from the telephone line in answering operation.

The record-reproduce procedure may be repeated any number of times, without penalty, until the customer is satisfied with the context and duration of his announcement. The previous recording is erased completely and automatically at the start of each ANNOUNCEMENT-DICTATE operation. Erasure takes place in the 3.5-second interval between the depression of the operate button and the appearance of the dictate light. When the customer is satisfied with his announcement, he turns the function knob to AUTOMATIC ANSWER. At this time, an amber-colored indicator, below the front panel engraving, AUTOMATIC ANSWER, lights to indicate that the machine is ready to answer an incoming call.

The same announcement may be left in the 2A set indefinitely and may be played back repeatedly without degradation of level or quality. Also, as indicated above, the announcement may be changed at frequent intervals without any detrimental effects whatsoever. The long life of the magnetic recording medium and the fact that it can be used without being handled by the customer are two major features of the 1- and 2-type telephone answering sets.

The 2A telephone answering set is basically a magnetic recording recorder-reproducer with a miniature switching system. One of its principal physical features is the sub-assembly construction, which consists of three units: the control unit, the 10A recorder, and the 152A amplifier. These individual units are manufactured and tested independently, and are completely interchangeable. The control unit and recorder are mounted on an aluminum die-cast base. This control unit, attached to the base, is shown in the background of Fig. 2.

Printed wiring techniques are used in the construction of the 152A amplifier, shown in the right foreground of Fig. 2. The "card" contains a three-stage speech amplifier and a recording bias oscillator. It plugs into a receptacle on the control unit chassis. Two miniature and two sub-miniature electron tubes are used. Filamentary-type tubes were chosen for their rapid heat-up, and sub-miniatures, in particular, for their low microphonics. The tubes are activated only during the operating periods; in the stand-by condition, while the machine is awaiting an incoming call, power is disconnected from the amplifier. This technique results in a long electron tube service life.

Switching within the control unit enables the same amplifier to serve for both recording and reproducing. To produce a consistently high, uniform and acceptable recording level, despite large differences in customers' voice levels, a combination of electronic level control and magnetic medium compression is used. A simplified automatic volume control circuit regulates the gain of the amplifier during the ANNOUNCEMENT-DICTATE function.

The 10A recorder illustrated in the center foreground of Fig. 2 consists of an aluminum die-casting upon which are mounted a drive motor, magnetic recording drum and head, erase coil, control solenoids and switches. The magnetic recording medium, "magnetic rubber," is a Laboratories development. It is made by combining magnetic iron oxide with an elastomeric material. Hypalon (a chlorosulphonated polyethylene made by du Pont) is currently used as the base material because of its high abrasion resistance combined with suitable elasticity. The long service life of the magnetic rubber cannot be matched, at this time, by the conventional forms of magnetic recording media, under the usage imposed by "answer only" service.

The magnetic recording head has the conventional ring-type construction. The same head is used for both recording and reproducing. It rides in contact with the surface of the recording band and traces

a helical track 0.042 inch wide. The head motion along the width dimension of the band is obtained by means of a half-nut and lead screw. The latter is driven by a gear train in synchronism with the recording drum. High frequency recording bias, approximately 15 kc, generated by the 152A amplifier, is applied with the speech signals to the recording head during ANNOUNCEMENT-DICTATE operation. This produces a remanent magnetization on the magnetic rubber recording band.

The remanent magnetization is erased by the "bulk" dc method with an erase coil mounted close to the recording band. Since the length of the erase coil pole-pieces is the same as the width of the band, the entire magnetic band is erased in one revolution of the drum – the first revolution of the ANNOUNCEMENT-DICTATE cycle. The dc erasure was chosen for its simplicity and low cost although a somewhat lower playback noise level could be achieved with ac erasure. A 40-db signal to noise ratio adequate for this type of service is readily obtained in the 2A set.

A telephone company installer can set the maximum announcement time to any value between 5 and 60 seconds. The actual announcement cycle duration is continuously variable, between the 5-second minimum and the setting established by the installer, under the control of a traveling limit switch. This switch is moved along by the recording head carriage during DICTATE operation and is clamped, in a position corresponding to the end of the announcement, at the instant the operate button is released.

The 10A recorder drive motor has a self contained worm-gear speed reducer. It is connected to the magnetic recording drum shaft through a flexible damping coupling. The drum shaft carries a flywheel, as part of a friction slip-clutch, to reduce flutter. The output shaft of the motor drives the recording drum at a speed of approximately 20 rpm, which, for the 4-inch diameter of the drum, corresponds to a peripheral speed of 4.7 inches per second at the recording head.

Fig. 3 — W. R. Goehner using a 2A answering set to test "magnetic rubber" recording bands.

The control unit of the 2A telephone answering set contains the front panel controls and indicators, the power supply, certain amplifier components including those of the automatic volume control circuit, and standard telephone-type relays for the high impedance ring-up, calling party disconnect and other control circuits. It also contains the connecting terminal boards for the telephone set and the telephone line.

Indications are that the demand for "answer only" service will continue to grow and that it will become an important customer service. Many sets are being used, with enthusiastic customer acceptance, in modes of operation extending beyond those originally anticipated. For example, a number of installations have been made for stock brokers who give their callers a brief, recorded indication of the condition of the market. Also, religious and other organizations use the service to transmit messages of an inspirational nature.

THE AUTHOR

C. M. TARIS received a B.S. degree in Physics from Yale University in 1948. After three years with the audio-video facilities development group of the National Broadcasting Company, he joined the Laboratories' Technical Staff. At the Laboratories, Mr. Taris has been engaged in the development of telephone answering sets as a member of the audio facilities development group. He is a member of the American Association for the Advancement of Science, American Institute of Physics, Institute of Radio Engineers, Society of Motion Picture and Television Engineers, Sigma Xi and Phi Beta Kappa.

Mass Spectrograph for the Analysis of Solids

A. J. AHEARN *Chemical Physics*

One of the problems that resulted from the expanded semiconductor research and development programs at Bell Telephone Laboratories in recent years was the analysis of impurities in semiconducting materials. These impurities are often present in such low concentrations that they cannot be detected with an optical spectroscope. A properly designed mass spectrograph might be suitable for these analyses, but such an instrument was not available. This problem in analysis was solved with a mass spectrograph designed and built at the Laboratories that proved to be sufficiently sensitive to detect as little as one atom of impurity in ten million atoms of a semiconductor.

A spectrograph is an instrument that identifies chemical elements or distinguishes among them by means of a spectrum of lines recorded on a photographic plate. In this class of instruments, those termed *mass* spectrographs reveal the composition of a sample of material by disclosing the masses of its constituent atoms and molecules. In a sense, the mass spectrograph is like the instruments of optical spectroscopy that identify the constitutents of a sample by separating the light emitted by the sample into a spectrum of colors or wavelengths. In another sense, however, the mass spectrograph more nearly resembles a centrifuge, since it is used to separate the atoms and molecules of a sample into a spectrum according to their masses.

The operation of a mass spectrograph is based on the fact that ions (electrically charged atoms or molecules) travel in a curved path in a magnetic field. If ions of the various elements that constitute a sample are accelerated by an electric field until they have the same kinetic energy, or energy of motion, they will travel in various curved paths depending only on the ratio of the mass of the ion, m, to its electric charge, e. These paths are described by the following equation: $r = (C/H)\sqrt{V(m/e)}$, where r is the radius of curvature of the ion path, C is a constant, H is the strength of the magnetic field, and V is the accelerating voltage used to impart kinetic energy to the ion. As indicated by the equation, once the magnetic field and accelerating voltage (H and V) are established in a mass spectrograph, the path of a particular kind of ion depends on the ratio of m/e. Thus, various ions can be separated.

To make practical use of this phenomenon, a mass spectrograph consists essentially of an evacuated chamber housing three components: first, a positive ion source – that is, a means for vaporizing the material to be analyzed (unless it is already a gas) and a means for ionizing the atoms and molecules of this vapor or gas; second, the analyzer that separates the ions according to their masses by the process described above; and third, the detecting system at the output of the analyzer for registering the appearance and intensity of the various ions that are resolved in the process.

Mass spectrometers are commonly used in various laboratories for the analysis of gaseous samples. In many plants, and particularly in petroleum refineries, they are also used in the control of some processes. A number of commercial instruments are available for gaseous analyses, and such an instrument is used at Bell Telephone Laboratories for analytical work.*

* RECORD, *February*, 1952, *page* 64.

Any mass spectroscopic analysis of a solid is basically more difficult than that of a gas. This is because the solid must first be vaporized. Once this is accomplished, however, the analysis is in principle like that used for a gas; in other words, the analysis consists of ionization, mass separation in an analyzer, and detection. Even today, however, commercial instruments for the analysis of solids are only in the "rumor" stage.

The large increase in the amount of semiconductor and other solid state research work done at the Laboratories since the war created a demand for the analysis of impurities in solids at and below the level of one part per million. Published work indicated that a mass spectrograph might be suitable for this purpose, and N. B. Hannay of the Laboratories undertook the design of such an instrument.

In the final design of the instrument, a spark formed in a high vacuum between electrodes of the

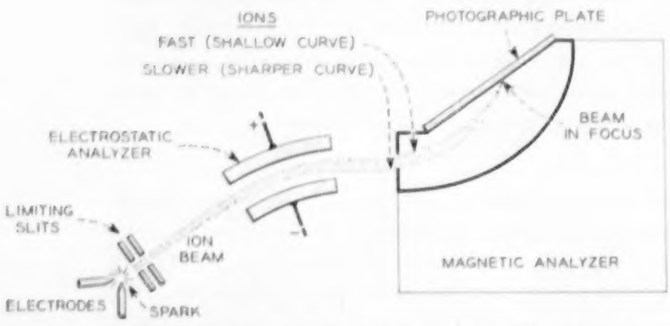


Fig. 1 — Diagram showing double focusing of ion beam in a mass spectrograph.

sample being analyzed is employed to vaporize and ionize the solid, thus providing the positive ion source. This source was chosen for several reasons. First, sample components vaporized in a spark gap contribute ions in proportion to their concentration, and are nearly independent of such factors as their vapor pressures. Also, since the spark is restricted to a small volume, heating is confined to the spark region, and contamination of the sample by its surroundings is minimized. Moreover, with a spark source, only minute quantities of the sample are consumed in an analysis. Finally, the spark source furnishes a quite general method of ionization.

In mass spectroscopy, the ion source chosen frequently dictates the type of analyzer employed. For example, in the instrument used at the Laboratories, an intense beam of positive ions is needed to detect the desired low concentrations of impurities. However, since positive ions travel radially away from the vacuum spark, those entering the analyzer form a divergent beam as shown at the lower left in Figure 1. Only a small fraction of this diverging beam would get through the analyzer were it not for the "direction focusing" employed. By this means, the initially divergent beam is converged, and thus the current through the analyzer is increased. But the ions entering the analyzer also have a wide range of velocities when a spark source is used. Only a small fraction – those within a narrow velocity range – would get through the analyzer but for the "velocity focusing" also employed. By this means, ions having a wider range of velocities pass through the analyzer, further increasing the current that contributes to the mass spectrum. Thus the choice of the spark source necessitates a "double focusing" instrument; that is, one employing both direction and velocity focusing derived from a suitable combination of electric and magnetic fields. At the detector, the ions are then separated according to their masses in sharply focused lines. Without both of these focusing conditions, the lines would be smeared out and unresolved. Furthermore, since photographic detection was to be employed extensively, the double focusing spectrograph constructed was of the Mattauch type. In this instrument, named after the scientist who first devised it, ions of every mass are simultaneously focused at the plane of the photographic plate.

The instrument can use either electrical recording or photographic detection, but the latter has been generally used because it can record all constituents of a sample simultaneously. Moreover with photographic detection, the ion current can be integrated or collected over a long period of time. In this way, impurities present at very low concentrations in a sample can be detected and identified.

With the Laboratories mass spectrograph, any material can be analyzed provided only that it can be vaporized by a spark in a vacuum. Bulk impurities, that is, impurities distributed throughout the volume of a metal or semiconductor, can be detected and identified. Surface contaminants, those impurities that appear as only a fraction of an atomic layer on the surfaces of solids, can also be distinguished from bulk impurities. The former appear only in the initial spark, whereas bulk impurities continue to be recorded on the plate in subsequent exposures.

With the mass spectrograph, antimony in germanium can be detected when the concentration is less than one atom to every ten million germanium atoms. Equally small concentrations of boron in silicon have also been detected. Although those de-

tectable concentrations are low, they are sufficient to produce large changes in physical properties of many solids. For instance, this amount of boron introduced into pure silicon changes its resistivity by a factor of 100,000.

Just as the boron ion and the much heavier antimony ion are equally detectable, most elements can be observed at this low concentration. Carbon, oxygen, nitrogen and hydrogen, however, cannot be detected in such low concentrations. These elements always appear as strong background lines derived from the residual gas present in this vacuum instrument. The mass spectrograph was not designed to be "baked out" to remove these elements during the evacuation.

In a typical study of surface contamination, an amount of indium equivalent to a single layer of atoms covering only 10 per cent of the surface was deposited on copper electrodes. In the subsequent analysis of these electrodes, the indium line was clearly visible in the initial exposure.

Insulators in powdered form can be analyzed by packing the material into suitable metal tubes which not only serve to contain the powder, but also to provide the necessary electrical conducting path for the vacuum spark. With this arrangement, the mass spectrum of the powder and that of the metal with its impurities are simultaneously recorded. Exposures made with a spark between a pair of the empty metal tubes make it possible to isolate the mass spectrum of the powdered insulator. Since this method requires that the sample be ground into a powder, surface contaminants become intermixed with the other constituents and therefore cannot be identified as such.

More recent work has shown that, at least with some insulators, a vacuum spark can be formed directly between the insulator and a metal. This can be done, for example, with quartz or steatite, a ceramic material now being used in electron tubes because of its excellent properties at high temperatures and at high frequencies. In this process one of a pair of metal electrodes is faced with a thin section of the insulator. Then, by applying a voltage in excess of the breakdown strength of the insulator, a vacuum spark between the insulator and the metal is obtained. The spectrum of the insulator can be isolated from that of the metal and the background by operating the spark directly between a pair of the metal electrodes. With this arrangement, insulators can be analyzed without first being crushed to a powder. Moreover, it is now possible to study surface contaminations on insulators. One steatite sample surface was deliberately contaminated with a layer of indium only two atoms thick. The resulting indium line was clearly visible, and a considerably thinner film could probably have been detected.

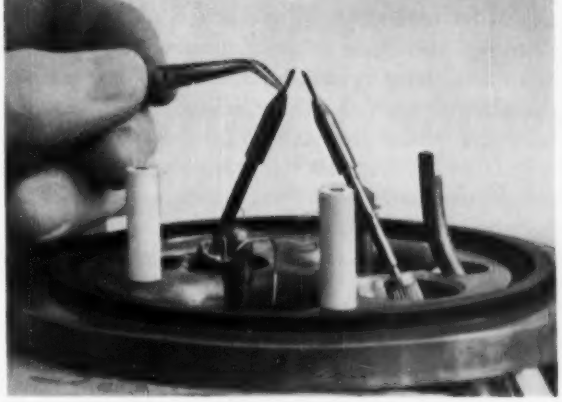


Fig. 2 — Electrodes used to furnish vacuum spark in the analysis of a solid.

A. J. Ahearn received an A.B. degree from Ripon College in 1923 and a Ph.D. degree from the University of Minnesota in 1931. He joined Bell Telephone Laboratories in 1929. At the Laboratories, Mr. Ahearn has worked on the field emission of electrons, secondary electron emission, electron microscope studies of thermionic emission, and the reflection of electrons from metals. During World War II he was engaged in work on magnetrons. Mr. Ahearn has also been concerned with bombardment conductivity in insulators, and at present is engaged with the use of mass spectroscopy in the study of solid materials. He is a Fellow of the American Physical Society.

In addition to the limitations previously mentioned for carbon, oxygen, nitrogen and hydrogen, there are also other selected cases where the optimum sensitivity cannot be attained. For example, the concentration of arsenic in germanium must be ten times that of antimony to be observed. This results from the fact that the arsenic line appears between two germanium lines which are necessarily overexposed. "Halation" which produces broadening of the lines in the emulsion results in an increase in the background darkening against which the arsenic line is invisible at a concentration of one part in ten million. The same limitation always arises for one or two impurity elements that are immediately adjacent in the periodic table to the principal constituents of the sample being analyzed.

This mass spectrograph for analysis of solid samples is best used for the detection of impurities in the concentration range extending from one part in 10,000,000 to one part in 100,000. For impurity concentrations greater than one part in 100,000, analysis can usually be made using an optical spectroscope. The mass spectrograph as described in this article is unique, however, in its ability to detect and identify surface contaminants where these films are less than one atomic layer thick.

Laboratories' Graduate Fellowships Awarded to Fifteen Predoctoral Students in Science and Engineering

Fifteen outstanding college students working for their doctor's degrees have been selected to receive the 1956 Bell Telephone Laboratories Graduate Fellowships. These fellowships, awarded for the first time this year, have been established to encourage predoctoral study and research in engineering and science related to communications technology. Each fellowship is for one year and carries a grant of $2,000 for the fellow and another $2,000 for tuition, fees and other costs to the academic institution he selects for his study.

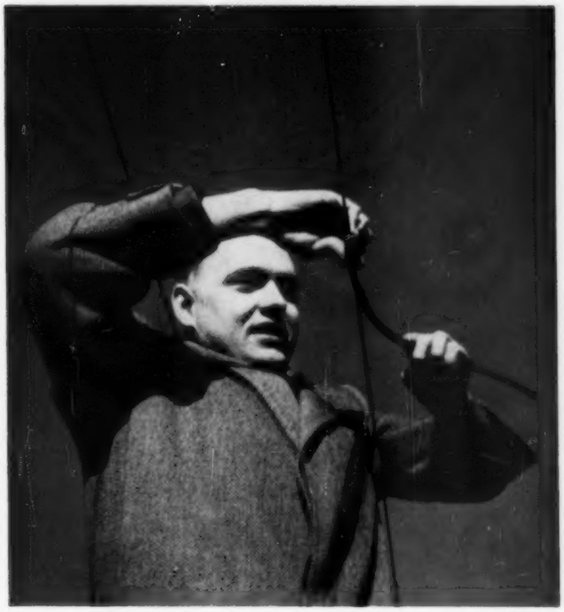
The Laboratories fellowships continue Bell System support of academic programs initiated more than ten years ago by the Frank B. Jewett Fellowships. In this period the Jewett Fellowships furnished an additional year's support for over fifty young scientists at the postdoctoral level to prepare for academic teaching and research. Now, because of the increasing depth and complexity of communications and electronics technology, training to the doctorate level in engineering and the underlying sciences is becoming as essential for many of those entering industrial laboratories as for academic teaching and research. The new fellowships are designed to aid more students in attaining this level of training.

The new Graduate Fellowship awards are based on candidates' demonstrated ability, the relevance of their graduate program to the broad field of communications technology, and the likelihood of their professional growth. Applicants are expected to include students in the field of electrical engineering, physics, mathematics, mechanical engineering, chemistry and engineering mechanics.

Awards are made on recommendation of the Laboratories Fellowship Committee in collaboration with the faculties of the applicants' schools. The Committee includes H. A. Affel, Chairman, R. L. Dietzold, K. E. Gould, J. A. Hornbeck, S. B. Ingram, W. D. Lewis, B. McMillan, S. Millman, and M. B. Long, Secretary.

The winners, fourteen men and one woman, include seven electrical engineers, three physicists, two mathematicians, two in engineering mechanics, and one chemist. They are as follows, listed with the institution where they plan to do their fellowship study:

Thomas F. Curry of Carnegie Institute of Technology, Donald L. Dietmeyer of the University of Wisconsin, Daniel G. Dow of Stanford University, Walton P. Ellis of the University of Chicago, Roderick Gould of Harvard University, Hermann K. Gummel of Syracuse University, J. Wilhelm Klüver of the University of California, Harold R. Leland of the University of Wisconsin, Tingye Li of Northwestern University, Lawrence R. Mack of the University of Michigan, James E. Mercereau of the California Institute of Technology, Harry C. Peterson of Cornell University, Mrs. Mildred Reif of the University of Chicago, Irwin W. Sandberg of Polytechnic Institute of Brooklyn, and Dana S. Scott of Princeton University.



A Line-Wire Vibration Damper

P. T. Packard installing a polyethylene vibration damper on a test-span line at the Chester Laboratory in New Jersey.

When a line wire is exposed to transverse winds, eddy currents of air are formed on its lee side. It has been found (see Figure 3) that these eddy currents alternate in position from areas near the top to areas near the bottom of the wire, and that this produces a vertical force which reverses direction with alternations in the eddy current position. At wind velocities above five or ten miles per hour, this alternating force attains a frequency which causes the wire to vibrate at one of the higher harmonics of its natural frequency. This frequency of vibration, however, varies with the wind velocity; the greater the wind velocity, the higher the frequency of vibration. Since the wind velocity at various points along even a one-hundred foot span is not constant at any one time, vibrations of several frequencies may be simultaneously imposed on the line wire. When the wire is rigidly clamped, the vibrations are reflected at the end points, and standing waves result. These waves combine to form a beat pattern which may be of sufficient amplitude to be visible to the eye, and the motion produces an audible noise commonly known as "singing."

Vibrations of this kind, with relatively large amplitudes, can have two adverse effects. First, when combined with a sufficiently high tension, stress in the outer fibers of the wire produced by bending at solid reflection points – such as supports or the abrupt change in cross section at sleeves – can result in fatigue breakage of the line wire. In addition, mechanical vibrations of steel line wire, by cutting the earth's magnetic field, may generate electromotive forces of sufficient magnitude to produce objectionably high noise levels in the circuit that is involved.

Test spans have been established at the Chester Laboratory to study these wire vibrations. It has been found that the most effective method of obtaining a record of the vibrations in these tests is to attach the armature of a sound-powered transmitter unit to the line wire, as shown in Figure 1. Voltages generated by movements of the wire are then amplified and recorded.

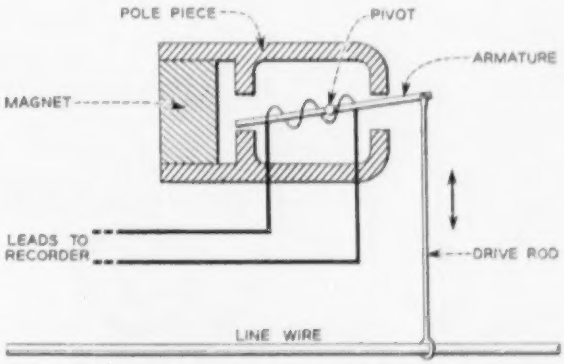


Fig. 1 – Sound-powered transmitter unit adapted for vibration studies to measure voltages generated by movements of the wire.

The detrimental effects of the vibrations can be avoided by decreasing the line-wire tension so that the combined tensile and bending stresses will be below the fatigue endurance limit of the wire. Another method is to apply a suitable damper to the wire to prevent the build-up of standing waves and thus reduce the amplitude of wire motion. Since reducing line wire tension – the first method – results in reduced ground clearance and possible undesirable contacts between wires, this method of obviating the trouble is not always satisfactory. As a result, the use of a vibration damper appears to be the most satisfactory solution to the problem.

After a series of tests, the dimensions and material required for a successful vibration damper were determined. It was found that the inside diameter of the damper should be roughly twice the diameter of the line wire on which it is to be used, while the length should be at least equal to a full wavelength of the principal frequency of wind-induced vibration. The damper was made flexible so that it does not form a reflection point along the span of wire, but has enough stiffness so that it can successfully damp wind-induced vibration. The damper, made of black polyethylene, is shown partially installed on a wire in Figure 2. It is formed of helically slit tubing, and is 18 inches long with a one-quarter inch inside diameter. The damper is readily installed by spiraling it on the line wire as shown on page 173. It was found to be equally effective when installed at any point on a wire span.

During tests at the Chester Laboratory, the amplitude of wire vibrations was reduced approximately one-hundred to one when this vibration damper was placed on a span. This reduction brings the bending stress to such a low value that the fatigue endurance limit of the line wire is not exceeded. In addition, the electromotive forces generated by the vibration of a damped steel wire are limited to an extent where the noise from this cause is no longer objectionable.

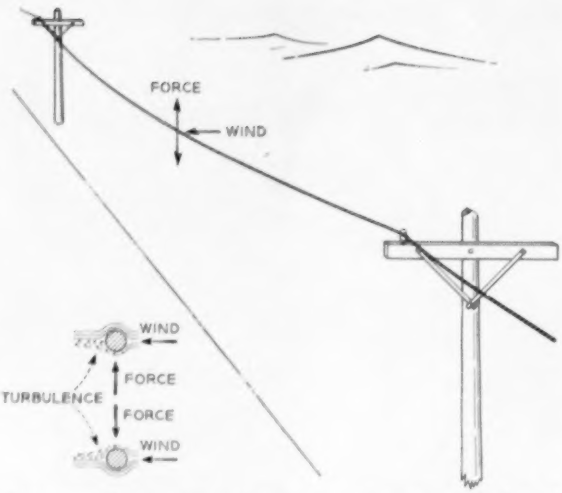


Fig. 3 — Line-wire vibrations are often produced by crosswinds with velocities in excess of five miles per hour.

P. T. Packard
Outside Plant Development

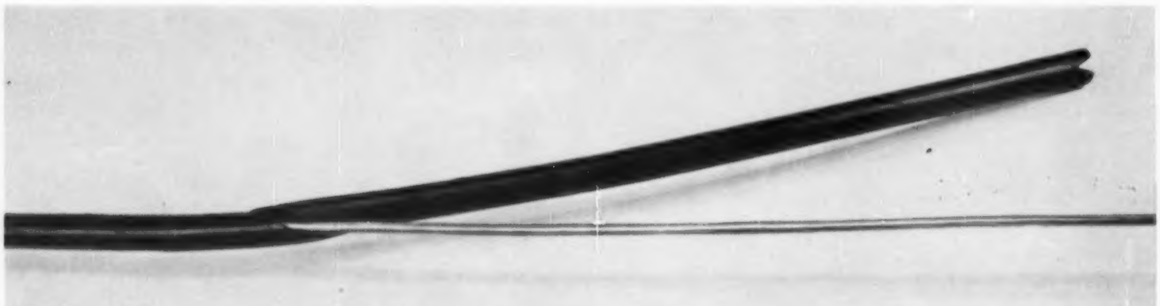


Fig. 2 — A polyethylene vibration damper partially installed on a wire.

Flexibility of the 43A1 Carrier Telegraph System

R. B. SHANCK *Special Systems Engineering*

In the fast-growing field of teletypewriter services, the 43A1 carrier telegraph system introduced a few years ago has shown amazing versatility. Although it is only one-third as bulky as its predecessor, it provides carrier telegraph channels both in and above the voice range over wide differences in attenuation, operates on several transmission media through comparatively high noise levels, and permits considerable choice in both line and loop requirements.

Keeping pace with the rapid growth and changing requirements of Bell System teletypewriter services, the 43A1 carrier telegraph system introduced a few years ago has been designed to operate under a variety of conditions. This system[1] transmits telegraph signals by shifting the frequency of each channel carrier; that is, each carrier is at one frequency for "marking" and another for "spacing" – the two line signaling conditions of telegraphy. These carrier frequencies may be above as well as within the voice range. Furthermore, the system is usable over a wide range of transmission loss, operates satisfactorily through comparatively high noise levels, and, in addition, provides convenient, economical on-off supervision for teletypewriter exchange (TWX) circuits.

Frequency allocations of the 43A1 system now provide as many as 17 two-way channels in the voice-frequency range, and four two-way channels above voice frequencies. These, of course, can be used in a variety of ways on different types of transmission facilities as indicated in Table 1. Open-wire, cable, and carrier telephone circuits can be used in the voice-frequency range, and open-wire and some types of cable circuits can be used at higher frequencies. A special carrier telegraph repeater is available for the latter services. Also, suitable radio facilities may be used where they are available.

To illustrate the versatility of this new system, consider how it helps to solve the problems of the layout engineer of an operating telephone company. Upon receipt of a service order for a new telegraph circuit, or an addition to an existing network, he must select telegraph facilities over available routes that will provide satisfactory service economically. In doing this he makes use of the telegraph transmission coefficients[2] of the facilities— a simple, numerical method of grading circuits – to determine whether any proposed layout will meet the transmission requirements. He must take into account the type of operation and speed, the locations of customer stations, the make-up of branches, and the effects of long-haul links that, in the proposed layout, will operate in tandem with the proposed facilities.

Long-haul links provided over "backbone" routes between large centers usually have 40-type voice-frequency carrier telegraph systems[3] available, which fulfill the requirements satisfactorily. If such

[1] B.S.T.J., *July*, 1952, *page* 666. [2] RECORD, *January*, 1955, *page* 11. [3] B.S.T.J., *April*, 1940, *page* 161.

facilities are not available, however, it will generally be in order to provide them by the installation of a 43A1 carrier system because the latter will operate as well or better, cost somewhat less, and require less space in the central offices. As may be seen in the headpiece, a 40C1 terminal requires the same space as three 43A1 terminals.

The layout problem, however, tends to become complicated when the extension of telegraph circuits to outlying points is involved. Until recently, such facilities were furnished largely by using ground-return dc telegraph circuits derived from the telephone circuits. With the introduction of carrier for telephone circuits connecting smaller towns and cities to larger centers over distances in the order of 20 to 200 miles, the proportion of dc circuits available has steadily dwindled. Furthermore, in many cases the dc circuits are used for telephone signaling purposes.

Accordingly, extension of the telegraph plant to outlying points is at present provided almost entirely by carrier systems. The 43A1 system is suited for use in small installations and is adapted to operation

Fig. 1 — Robert B. Santos, Telegraph Serviceman at Long Lines, checks the operation of a 43A1 channel terminal.

on voice circuits and on the various carrier telephone systems. The branching off of one or more channels at an intermediate point is readily achieved so that circuit requirements may often be met by combining individual channels into a group or "system" of appreciable size, such as 6 to 17 telegraph channels.

Where only a few telegraph channels need be provided, it is in order where practicable for the layout engineer to obtain these by using 43A1 channels above the voice band. For example, four two-way

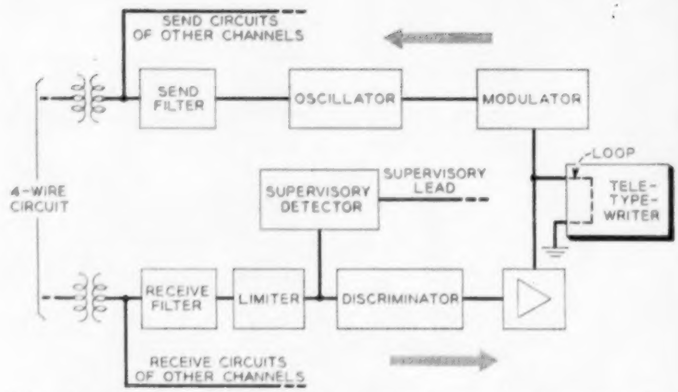


Fig. 2 — Diagram of a 43A1 channel terminal arranged for half-duplex operation from a four-wire circuit.

channels may be obtained between the voice band and type-C carrier on open wire, or two two-way channels above the voice band on 19H88 four-wire cable. In many cases, branch connections may also be employed at the frequencies used. Furthermore, flexibility is augmented by the possibility of using a variety of telegraph levels as long as no receiving level drops further than about 45 db below one milliwatt.

Another factor that is often of considerable importance in giving economical service is the location of telegraph channel carrier equipment at an outlying customer station. A 43A1 channel terminal may be located in the customer's office in a small metal box attached to the teletypewriter table, avoiding the necessity for skilled attendants at an outlying central office where few or perhaps only one telegraph circuit would pass through that office. Alarm features provide that personnel, at both the distant central office where the channel is terminated and at the customer station, will receive an indication if the line circuit is interrupted.

Design of the equipment provides a higher degree

TABLE I — FREQUENCY ALLOCATIONS AVAILABLE

	Channels	*Frequencies (cps)*
In voice range	17	425 to 3145
Above voice, 19H44 4-wire cable	8	3550 to 5050
Above voice, 16H44 2-wire cable	4	3550 to 5050
Above voice, 19H88 4-wire cable	2	3550 and 3750
Above voice, 19H88 2-wire cable	1	3550 and 3750
Between voice and type-C carrier on open wire	4	3550 to 5050
Between voice and type-H carrier on open wire	1	3550 and 3750

of physical as well as circuit flexibility. Channel terminals are of the "universal" type; layout rearrangement is facilitated by the use of plug-in networks for convenient change of frequency assignment. When the carrier equipment is located at a customer station, on-off supervision from the customer to a switchboard is made possible economically by circuits that recognize on-off conditions of the carrier.

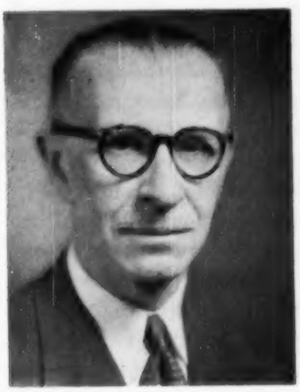
Local dc connections to teletypewriters may be either full or half duplex, depending on requirements. Full-duplex operation provides simultaneous two-way transmission while half-duplex, Figure 2, permits transmission in both directions but not at the same time. Customers may be connected to a central office by up to about 25 miles of cable without the need for special circuits to reduce loop-circuit signal distortion. Where serviceboards* are used for switching or testing, 43A1 units may be connected directly to the electronic hub circuits in the serviceboards. In addition, the carrier terminal equipment may be located at the customer station when this is preferable to dc loop operation.

Channel terminals are completely electronic, and the plug-in feature permits easy, rapid changes of frequency assignments when necessary. Other changes, such as those required to meet local circuit conditions, are made by strapping. Units located at customer stations, or at central offices not having 130 volts dc available, are operated on small ac power packs using commercial power.

Developed originally for short-haul service, the 43A1 system meets substantially all the present telegraph transmission requirements so that it is not only replacing dc facilities for such use but is also preferred for new circuits in the long-haul field. Its many possible uses, small size, power requirements, and simplicity of installation and changes have made it so popular with the Operating Telephone Companies that production has already far out-stripped that of the older 40-type equipment.

* Record, *March*, 1955, *page* 100.

Fig. 3 — Peter A. DeCarlo removes a channel terminal from the bay.



Roy B. Shanck spent his summers with the A. T. & T. Co. in Ohio while attending Ohio State University. Upon receiving the degree of B.E.E. in 1915, he joined the Engineering Department and four years later the Department of Development and Research. While there, and subsequently after transferring with his department to the Laboratories, he engaged in communication development work relating largely to telegraph transmission and the application of telegraph systems to circuits in the Bell System. During World War II, he was concerned with development work on communication systems for the Armed Forces. Mr. Shanck holds several patents relating mostly to telegraph and signaling, is a member of A.I.E.E., and is a senior member of I.R.E.

As part of the continuing effort to simplify and economize operating procedures, the Laboratories has investigated chemical control of brush along telephone rights-of-way. Some of the chemicals ordinarily used for weed control also kill the heavier and woodier plants. Extensive field tests indicate that three of these new plant-killing chemicals can do an effective job at lower cost than manual methods.

O. A. HANNA *Outside Plant Development*

Chemical Brush Control

With the issuing in 1955 of a specification for brush-control chemicals to be used by the Bell System Companies, some ten years of extensive Laboratories' study was culminated successfully. The specification sets requirements for three chemicals used to control roadside and right-of-way brush, namely "Ammate" (ammonium sulfamate), "2, 4-D" (various esters of 2, 4-dichlorophenoxyacetic acid), and "2, 4, 5-T" (esters of 2, 4, 5-trichlorophenoxyacetic acid).

The Laboratories' investigation for a method of controlling unwanted brush by chemical means was begun in April, 1945, in response to a request from the American Telephone and Telegraph Company. Because of the extension of rural aerial telephone plant where minimum ground clearances were expected, it was important to keep the underbrush from coming into contact with the wires. The desirability for keeping construction and maintenance costs low also provided a very considerable impetus for investigation.

Prior to the development of brush-killing chemicals, it had been the practice to clear brush from rights-of-way by manual cutting with axe and brush hook or by other mechanical means. Such cutting, which was necessary every two or three years, stimulated growth of many new shoots for each shoot that was cut. After several such operations, many rights-of-way became virtually impenetrable. Since annual shoot growth often exceeds six feet, the hand cutting of brush, while necessary, was at best a costly practice.

In 1945, two chemicals, Ammate and an ester of 2,4-D, were being used with considerable success for the suppression of weeds. It was proposed that these two chemicals might also kill brush. Several small test plots were established at the Chester, New Jersey, field laboratory, and many different chemical materials were tested. Periodic examination of these plots showed Ammate and 2,4-D to be the most promising. At sufficiently high concentrations, the Ammate, a non-selective chemical, killed all vegetation, including woody shrubs and grasses. The 2,4-D, however, is a hormone or synthetic chemical – one which is actually translocated or carried into the plant's internal system. It was more selective in its action; broad-leaved plants were killed, but grasses were not harmed materially. It was noted also that while some species of shrubs were killed, 2,4-D had little effect on certain other species.

In the next two years additional test plots were laid out and observations were made of full-scale commercial applications on rights-of-way of both telephone and power companies. By the fall of 1948, it was evident that chemical brush control offered very definite promise. Another new material, 2,4,5-T had become available commercially and was reputed to be more effective against certain of the hard-to-kill species, such as oak, ash, hickory, and red maple. It was at this time that the Laboratories' studies were accelerated. Because of the considerable difficulties encountered in obtaining data accurate enough for the specialized needs of the Bell System, the decision was made to extend the test

program. In 1949, following additional test-plot work at Chester, two full-scale field trials were planned in cooperation with the Bell Telephone Company of Pennsylvania and the American Telephone and Telegraph Company. The field trials had been planned as continuing projects to be of sufficient duration to provide comparative data on the proper programming of treatments, relative costs, and effects of various sprays and spraying methods over a five-year period. While the broad purposes of the trials were quite similar, the emphasis in the first trial was placed upon evaluation of the effect of chemicals when properly applied. In order that proper application could be insured, Laboratories engineers did most of the actual spraying. The emphasis in the second trial was placed on relative cost and the effectiveness of chemical brush control as done by a regular commercial contractor.

The first test right-of-way was located about five miles north of Hamburg, Pennsylvania in rugged terrain which drops from an elevation of 1300 feet to 500 feet in less than three-quarters of a mile (see headpiece). The line was cleared in the fall of 1949 and three different methods of treatment were applied in the spring of 1950. In July of 1950 a plant inventory of the test area was made and compared with an original inventory. All of the treatments were termed successful with Ammate spray showing up particularly well. It was definitely established that properly applied, any of the materials tested would do an excellent job in establishing brush control by chemical means.

The second test area selected was a 6.3-acre section in the Philadelphia-Allentown toll cable right-of-way north of Lansdale, Pa. In September, 1949, 4.1 acres were treated with a 50-50 2,4-D/2,4,5-T water-borne spray and 2.2 acres were treated with Ammate. Untreated control areas were left in each plot. Examination the following year indicated that something had apparently gone amiss. The brush on the Ammate area appeared to have a high degree of kill, but the results on the 2,4-D/2,4,5-T area were very disappointing; the kill was less than 15 per cent. The poor kill was attributed primarily to the lateness of the season. A heavy frost had occurred several weeks after application of the spray, and the plant processes necessary to translocate the chemical down the stem and into the roots of the plants had apparently been arrested by the frost. It was necessary, therefore, to respray this section completely in July, 1950. The section treated with Ammate was in excellent condition, but showed some resprouting of resistant species. This section was not sprayed in 1950 but was resprayed in July, 1951. Inspection of the right-of-way in 1953 showed better than 90 per cent control on both areas. In 1954 the brush in the untreated control areas was cut and the stumps were treated with 2,4,5-T in oil. This brush, which had not been cut since 1949, had attained a height of between 12 and 18 feet, and in several places was above the cable and strand. By comparison, the sprayed areas were under excellent control with a healthy growth of annuals and grasses having replaced what would have been impenetrable brush. The few shoots remaining were sprayed from a knapsack tank. The test area has now been declared completely under control, and it is believed that an occasional inexpensive spot spray from knapsack tanks will be sufficient to keep the area under control in the future.

Several items of importance emerged from the work on the two test lines: First, it was demon-

Fig. 1 — (left) Roadside right-of-way in Pennsylvania test showing undergrowth of brush before chemical spray; (right) same area after control by chemical methods.

Fig. 2 — Burlington-Kansas City cable route (left) before chemical treatment (1947) and (right) after treatment (1953). Nearly impenetrable brush, sometimes reaching as high as the cable and strand, has been replaced by a healthy growth of annuals and grasses.

strated that over a six-year period exceptionally good control of an area may be obtained with one complete treatment, one partial treatment and one spot spray. Second, Ammate appeared to be more effective as an initial spray than the 2,4-D/2,4,5-T treatment. However, the advantages of Ammate were somewhat nullified by its tendency to corrode spraying equipment. A thorough cleaning of all tanks, pumps, and associated equipment was found to be imperative after each day's operations. Finally, experience indicated that the best time to apply a foliage spray is during the growing season, April through July, when movement of fluids between the foliage and roots of the plants tends to translocate the chemical throughout the plant.

The second trial near Landsdale, Pa., also yielded some important information about the relative costs of chemical control versus hand cutting. Over the six-year period of the test from 1949 to 1955, the average cost per acre per year was still somewhat higher than the corresponding average for manual cutting. However, once the brush was eliminated, the yearly cost of maintenance by chemical methods dropped to about eight dollars per acre, which is approximately twenty per cent of the cost of hand cutting. These figures apply only to a small-scale field trial in one section of the country, but they do indicate the great savings to be realized through the practice of chemical brush control on telephone rights-of-way.

Orville Allen Hanna received a B.S. degree from the University of Minnesota in 1947, majoring in forestry and wood technology. He had previously served 3½ years as pilot in the Army Air Forces, spending 1½ years in Europe. After graduation, Mr. Hanna worked in sales and sales promotion in the Chicago area, joining the Laboratories in July, 1949. His work with the Outside Plant Development Department has included studies on strength of poles and cross-arms, both solid and laminated, wood preservation, chemical control of woody brush on rights-of-ways, and design of mock-ups on Nike. At present he is engaged in the design and development of a new lightweight, non-conducting extension ladder.

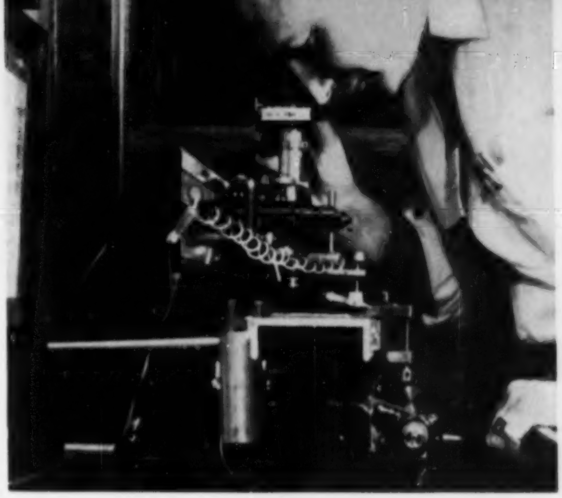
Engraving a 58-Inch Linear Scale

Part of the work of the Precision Measurements Laboratory is engraving division lines on linear scales. Typical scales required are those used for calibrating toolmakers' microscopes and for calibrating the transverse settings of milling machines with a microscope. None of these scales exceeds three inches in length. Recently, however, it became necessary to adapt and expand these techniques for engraving small scales to fulfill a request for a scale 58 inches long. This scale was to be used in the checking of potentiometer cards.

Potentiometers are used in a great many different types of analog computers* and servomechanisms, and the accuracy with which a computer or servo can operate is determined primarily by how accurately the potentiometer represents the physical or mathematical function involved. A very accurate scale is one component of the measuring apparatus used to explore the resistance element of the potentiometer, and it was this scale that the Precision Measurements Laboratory was asked to produce.

The instrument used for engraving the special scale is a line comparator built on special order in 1922 for the Engineering Department of the Western Electric Company before it became Bell Telephone Laboratories. Built by the Société Genevoise D'Instruments De Physique in Geneva, Switzerland, the instrument is a simple device for comparing two linear scales up to one yard in length. Micrometer microscopes permit readings of 0.00005 inch. One scale is a "standard yard" made of 58 per cent nickel steel, an alloy with an accurately known temperature coefficient that is highly resistant to oxidation and rust. The division lines are very fine and sharp, with a width of about 0.0001 to 0.0002 inch. To use the instrument for engraving, a diamond stylus and a means for its longitudinal adjustment had to be added at the Laboratories. The comparator is kept in the Precision Measurements Laboratory at 68 degrees Fahrenheit, the temperature at which the standard yard is calibrated by the United States Bureau of Standards.

* Record, *May*, 1954, *page* 171.



The author checks position of the engraving stylus by reading the standard scale through a microscope in the Precision Measurements Laboratory.

Fig. 1 — The stylus is traversed to mark the new scale by operating a hand-wheel.

The desired scale was to be 58 inches long with lines spaced 0.1 inch apart. The tolerance was plus or minus 0.0002 inch for each increment and the cumulative error could not exceed 0.001 inch at 78 degrees Fahrenheit for the entire length. To correct for expansion of the stainless-steel scale engraved at 68 degrees and ensure that the markings would be within the prescribed tolerances at 78 degrees, a compensating factor was employed for determining the actual dimensions to be engraved.

Since the scale length was greater than that of the comparator, special arrangements were made to add a long aluminum U-shaped channel to the comparator to support the scale during the engraving operation. Again, because of the extra required length, the engraving had to be accomplished in two separate operations. Lines were engraved from 0 to 36 inches and the scale was then moved to a new position. After aligning the last engraved line with the comparator microscope, the remaining 22 inches were engraved.

This particular job is typical of some of the out-of-the-ordinary requests fulfilled by the Precision Measurements Laboratory as a vital part of the successful achievement of many important projects.

R. F. Heinrich
Switching Apparatus Development

Traffic Counting with Line-Insulation Test Frame

H. W. FLANDREAU
W. H. BERCH
Switching Systems Development

After new systems and apparatus have been developed to fulfill needs brought about by the ever-growing Bell System communications networks, additional requirements are often encountered which can be satisfied by modifications of the existing equipment. Such modifications may result in considerable savings of money, time, and space. For example, the line-insulation test frame, originally designed to detect incipient troubles on customer telephone lines, was found well suited, with relatively minor modifications, for use in making traffic-count studies in No. 5 crossbar offices.

A test circuit for measuring the insulation resistance of customer telephone lines in No. 5 crossbar offices* has been modified to include the additional function of making traffic counts. Before describing this circuit, however, it is necessary to explain why testing insulation and making traffic counts are necessary operations of any telephone office. Insulation testing is necessary since a decrease in resistance of the insulation of telephone wires is often an advance warning of trouble, and maintenance action can be taken before service to the customer is impaired or interrupted.

The reason for traffic counts is perhaps a little more involved, but it can be explained quite simply. It is generally known that to design a telephone office so that each customer has individual equipment for his use only would be economically impossible. Instead, the office equipment allotted to each customer is comparatively small – a single relay and a vertical unit on a crossbar switch. All the rest of the equipment in the office is shared by a number of customers. Traffic-count data are important in seeing that this sharing of equipment is equitable, so that each customer has only a very small chance of being denied service because the equipment is tied up by other calls. Such service limitations are most probable during the "busy hour," and traffic counts are vital to the determination of the best possible distribution of equipment so that the very great majority of busy-hour calls get through without delay. They are also vital during periods of change or modification of the telephone office, since high quality of service must be maintained under new arrangements.

The line-insulation test circuit is well suited to take on the job of traffic counting, because it connects to a customer's line by means of an idle line link. This, of course, requires that the circuit "look" at the line links to pick out one that is not busy. It was a natural step, then, to use the number of

* RECORD, *October*, 1954, *page* 393.

links found busy as the basis for a traffic count.

Figure 1 shows a path from a customer on one of the ten horizontal groups of a line-link frame to a trunk on one of the ten horizontal groups of a trunk-link frame. This diagram illustrates in simplified form the two test points used in the traffic count. At the left of the diagram, the test point in the line-link frame was already used as a part of line-insulation testing; however, for the purpose of traffic counting it was necessary to add a similar circuit to "look" at the trunk connections.

The value of the traffic information obtained with the test circuit can be appreciated with a simple illustration. When a customer starts to place a telephone call in a No. 5 crossbar office, there are initially ten possible circuit connections that can be made from his line switch, and his call will be forwarded if any one of these ten circuits is idle. If his is a low-usage line, he may share these ten outlets with as many as fifty-eight (usually fewer) other customers; only under unusual circumstances will all ten connections be busy. A business telephone, however, could share outlets with only a very few other lines, because of the high usage rate. Traffic count data therefore help to answer such questions as: How many customer lines should be serviced by the ten horizontal connections of a line-link crossbar switch? The data also help to answer a question like this: Since it is necessary to re-allocate customer lines on the line-link frames because of the growth of the office, how shall the distribution be made so that all customers will encounter the same chance of finding all paths busy?

Five different types of traffic counts can be made with the modified line-insulation test frame. These counts are called: Line-link office count, line-link frame count, trunk-link frame count, line-link horizontal group count, and trunk-link horizontal group count. The line-link office count is used to determine the total traffic through an office, and the results can be used for engineering additions to that office. The two frame counts are used to determine the distribution of traffic to each line-link frame and trunk-link frame within the office. The two horizontal group counts determine the distribution of traffic to each of the ten horizontal groups or switches on each frame. Results of these counts can be used to establish a balance between the lines and trunks on their respective frames so that all possible connecting paths are used efficiently.

The same busy test method is used for traffic counts as in line insulation testing, but for traffic counts, the links found busy are indicated on ten traffic registers. In line-link office counts where the total number of busy line links in an office is determined, all the line-link sleeves are tested during a cycle. In this case, tests are made on each horizontal group of each line-link frame by connecting ten relays in the test circuit to the corresponding ten line links. Each busy line link operates a test relay and an associated register. Since this procedure includes each horizontal group on each line-link frame, the sum of the indications on the ten traffic registers is the number of busy links in the office.

Frame counts and horizontal group counts are also made by testing the link sleeves, but in these counts one register is associated with each frame or horizontal group tested. This is done by an additional set of ten relays which count the number of busy links and operate the traffic registers. Each of these relays is associated with one of the ten links that is to be tested on a particular horizontal group in a given frame seizure.

A line-link frame count is made on ten line-link frames during a cycle, one register being associated with each frame. Each of the ten registers operates once for each busy line link on the respective frames. Trunk-link frame counts are made in a similar manner, but only five trunk-link frames are tested during a cycle. The testing time is approximately the same as that for ten line-link frames, since a trunk-link frame has twice as many links.

Horizontal group counts are made on the link sleeve leads of one line-link or trunk-link frame at

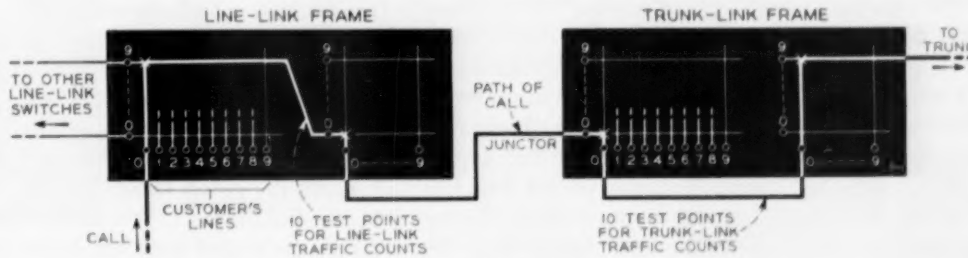


Fig. 1 — Simplified schematic showing connections for a path through a No. 5 crossbar office.

a time. One register is associated with each horizontal group or switch on the frame being tested, and each register operates once for each busy link encountered in the corresponding horizontal group.

Just as for line insulation testing, access to each of the link leads is made by connecting to the multiple between the line-link frame connectors or the trunk-link frame connectors and one of the markers. This arrangement is shown in the block diagram in Figure 2. The facilities for connecting to the line-link frame connector multiple were already available since they were provided for line insulation testing before the traffic count feature was added. Similar facilities have been added for traffic counts of the trunk links. As shown in Figure 2, with the CO- (cutoff) and TCO- (trunk cutoff) relays unoperated, the line-link frame and trunk-link frame leads are connected to the marker. With the CO- and CI- (cut in) relays operated, the line-link frame leads are switched from the marker to the line insulation test frame. The trunk-link frame leads are switched in a similar manner by operating the TCO- and TCI- (trunk cut in) relays.

Progress through the appropriate frames for each count is made in three-minute cycles, but these cycles can be repeated automatically to obtain an average count over a longer period. A cycle could easily be completed in less than three minutes, but this interval is used since it is considered to be the average duration of a telephone conversation. If the required link leads for a count are tested group by group in succession during a three-minute interval, each busy indication that is encountered will represent a link that is busy for an average of three minutes.

As a means of keeping interference with the normal flow of traffic at a minimum, the three-minute testing interval was divided into ten sub-intervals of 18 seconds each. During each 18-second sub-interval there is a work period in which all the horizontal groups having the same designation in the appropriate frames are tested. A waiting period then follows for the remainder of the sub-interval. During the waiting time, which is usually longer than the work period, all connecting circuits are free for normal service to telephone customers.

Using a line insulation test frame for traffic studies requires only a few manual operations. Once a count is started by traffic personnel, the circuit automatically completes the test. Regardless of the type of count that is to be made, a key on the traffic register cabinet is operated to start the test frame, and this key is restored to normal to stop the cycle

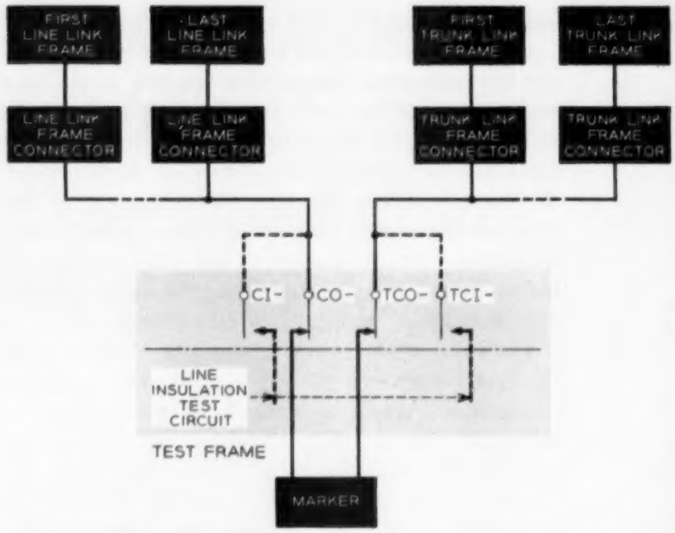


Fig. 2 — Block diagram showing connections to a line insulation test circuit in a No. 5 crossbar office.

after sufficient data has been obtained on the traffic registers. The type of count to be made is controlled by the operation of a group of keys and switches at the line insulation test frame as shown in the headpiece of this article.

When a line-link office count cycle is started, the marker associated with the line insulation test frame is made busy. The line-link connector multiple is then disconnected from the marker, and the leads required for testing are connected into the test circuit as shown in Figure 2. After the test circuit has checked these connections, a bid is made for access to line-link frame 0 in the same way that the marker would bid for that frame in normal operation. When the frame is seized, the connector relays and the relays associated with horizontal group 0 are operated. This connects the ten line-link sleeve leads to the test relays, and the traffic registers are operated for each busy link encountered. The line-link frame is then released. This cycle continues by advancing the group selection relays to bid for access to line-link frame 1. When this frame is seized, the relays associated with horizontal group 0 are operated, and the ten line-link sleeve leads are thereby connected to the test relays. The traffic registers again record the busy links encountered, and the frame is released. The group selection relays are advanced and the line-link sleeve leads on horizontal group 0 on each remaining line-link frame are tested in a similar manner. After the line-link sleeves are tested on horizontal group 0 of the last line-link frame, the line-link connector multiple is re-

leased, and the marker is again made available for service calls.

In a central office with a maximum of 40 line-link frames, this part of the cycle is completed in approximately seven seconds. After the "waiting period" – the remainder of the 18-second interval – the marker is again made busy and the line-link connector multiple is reconnected to the test circuit for testing the line links in horizontal group 1 of each frame. The cycle continues over each horizontal group and each line-link frame until all are tested and an "end of cycle" register is operated.

The other traffic counts are made by seizing the frames and testing the links in a manner similar to that described for the line-link office count. For frame counts, the tests for busy links progress from frame to frame the same as for the line-link office count, except that the number of frames is restricted to ten for line-link frames and five for trunk-link frames. Since horizontal group counts are restricted to one frame, testing progress is from horizontal group to horizontal group on the same frame.

To stop a count, the key at the traffic register cabinet is restored to normal. This stops the test after the cycle in progress has been finished. Readings on the traffic register are recorded, and the total number of busy registrations determined. The total number of cycles is indicated on the "end of cycle" register. If additional counts are not required, the frame can be restored to normal by operating the "restore to normal" key labeled RN at the line insulation test frame. This key can also be used to restore the circuit to normal at any time during a cycle if desired.

To check for correct operation of the counting circuit, test resistors can be connected to the corresponding test relays so that the same current is produced as when a busy link is encountered during a test cycle. As a result, any combination of busy conditions on the ten links can be simulated, and the results indicated on a special test register.

It is expected that considerable savings to the Operating Telephone Companies will result from the use of this frame for line-link and trunk-link traffic studies. Since many of the features of line insulation testing are used for traffic counts, the cost is substantially lower than it would be if a separate frame were required. It should be pointed out, however, that this traffic count feature is not to be considered a substitute for the Traffic Usage Recorder which is the permanent usage measuring device now available. The traffic feature of the L.I.T. frame was developed as an interim device and cannot measure usage for common-control equipment or trunks.

THE AUTHORS

H. W. Flandreau received his E.E. degree from Rensselaer Polytechnic Institute in 1920. That same year he joined the Installation Department of the Western Electric Company where he was engaged in the inspection and testing of panel system equipment. In 1922, he transferred to the Laboratories, then the Engineering Department of the Western Electric Co. Except for an initial period spent in preparing specifications for testing and maintaining panel system equipment, and in ringing studies, he has been concerned principally with the testing of various dial system circuits.

W. H. Berch joined Bell Telephone Laboratories in 1945 as an assembler and wireman. From 1948 to 1950, as a technical assistant, he was concerned with maintenance and planning in the crossbar switching laboratories. In 1950 he transferred to the No. 5 crossbar development organization and assisted in laboratory testing of circuits for that project including the line insulation test circuit. He attended the evening division of the Polytechnic Institute of Brooklyn and received the degree of B.S. in E.E.

Installing cable with the new guide. Not shown here, a workman directed traffic around the crew.

Aerial Cable Guide

Ever since aerial cable began to be used as a medium for telephone transmission, engineers have been faced with the problem of supporting the cable. Many methods have been employed, including hooks, rings, clips, and lashing wires. More recently, the cable is prelashed to its supporting strand on the ground before the strand is mounted on the poles.* Where conditions permit, direct lashing of the cable to a previously mounted strand has proved to be one of the most economical methods, since it does not require the placing and removing of temporary cable supports. Direct lashing is possible wherever the cable reel and towing vehicle can be operated on the same side of the poles as the strand.

In direct lashing, after one end of the cable is anchored to the strand or to a pole, the cable is payed off the reel as it is pulled along the pole line by a tow truck. A cable lasher† is pulled along the strand, wrapping a steel lashing wire helically around cable and strand. A cable guide is also pulled along a few feet in front of the lasher, to guide the cable into position near the strand and through the lasher. Transferring the cable guide past the poles is a time-consuming operation. The guide previously used had to be lifted off the strand, carried past the pole, and replaced on the strand. This was difficult to do, even with the smaller, lighter cables, since the cable also must be supported during the transfer. For the heavier cables, a block and tackle were sometimes required. The cable lasher must also be transferred.

A new cable guide incorporating several additional features has been developed at the Laboratories, and is now being furnished to the Operating Companies. This steel guide, Figure 1, is basically the same as the original guide. The original guide was a curved steel chute, supported from the strand by a single arm with a roller, that guided the cable into place in a gentle curve. A clevis and pin at the rear kept the guide aligned with the strand. The

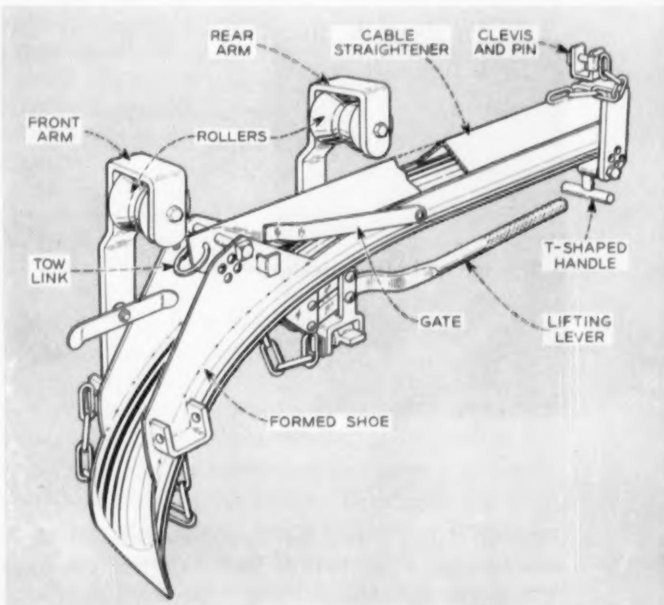


Fig. 1 — A sketch of the new guide. The two support arms are shown on the far side for clarity, but may be used on either side as desired.

* Record, *May*, 1955, *page* 161. † *May*, 1941, *page* 270.

new guide is similar, but has two support arms, each of which can be swung out sideways away from the strand. In addition, the rear arm is connected to the guide through a lever arrangement so that the front of the guide can be raised or lowered with respect to the rear arm by pressing down or lifting up on the lever. Rollers on both arms are much wider than those on the earlier guide, to facilitate passing the guide over mechanical splices in the strand.

A workman can literally "walk" the new guide past a pole, without actually removing it from the strand. When the guide is pulled to where the front arm is past the pole and the rear arm is stopped by the cable-suspension clamp, Figure 2, the lineman moves to the cable side of the pole. He presses down on the lever and, since the guide is supported by the rear arm, raises the front of the guide to where he can swing the front arm into position over the strand and lock it into place. Raising the lever to its normal position leaves the guide supported by the front arm *ahead* of the pole and the clevis *behind* the pole. The rear arm is now above the strand, Figure 3, and may be swung out from the guide after its locking gate is opened.

The guide is then pulled further along until the rear arm is past the pole. Now, the workman returns the rear arm to its normal position and locks it in place. If he wishes, he can remove the clevis pin and have the guide pulled along until the clevis passes the pole, Figure 4. After re-inserting the clevis pin above the strand as before, he can then press down on the lever and swing the front arm away from the strand, leaving the guide in its normal position but *past* the pole. Alternatively, he can return the rear arm to position, raise the guide, swing out the front arm, have the guide pulled forward, and then release the clevis pin to permit the clevis to pass the pole. In the first case, the guide is supported by both arms during this part of the transfer; in the second case, it is supported only by the rear arm. In either event, a T-shaped handle below the rear of the guide permits the workman to control its position as the clevis passes the pole. Once the guide is clear of the pole, the cable lasher is transferred in the usual manner.

In addition to minimizing the amount of work and equipment required, Operating Companies indicate that the new guide can be transferred in one-third to one-half the time previously needed, and that the safety of the workman performing the transferring operation has been appreciably improved.

S. R. King
Outside Plant Development

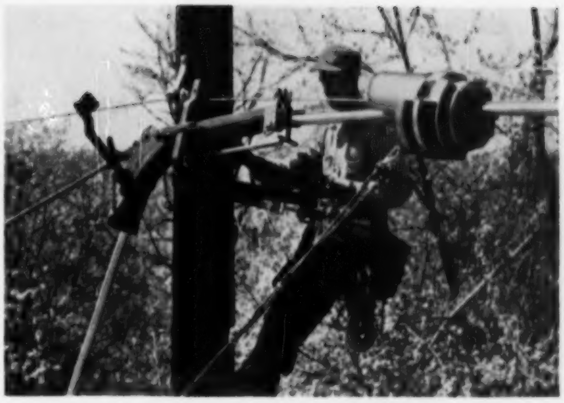
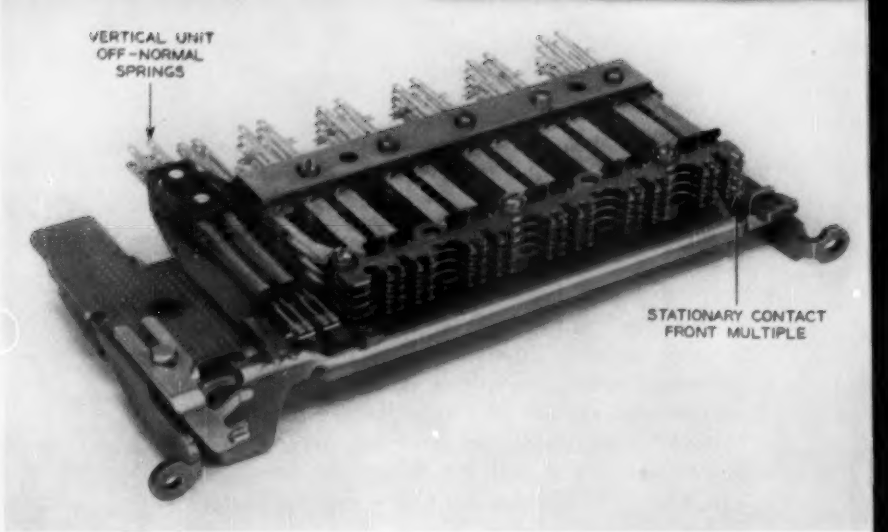


Fig. 2 — The tow truck is stopped when the rear support arm nears the strand support.

Fig. 3 — Raising the lever lifts the rear arm above the strand when the guide is supported on the front arm and the clevis, permitting the rear arm to be swung toward the workman to clear the pole.

Fig. 4 — The workman, Otto P. Stemler, Jr., New Jersey Bell lineman, signals to halt the tow truck as the clevis passes the pole.

The Post-War Crossbar Switch



C. C. BARBER

Switching Apparatus Development

Immediately after the end of World War II, the demand for telephone service increased tremendously, at a time when material and manufacturing costs were rising rapidly. To meet this situation, economies in methods of manufacture and a redesign of the crossbar switch were achieved by incorporating several cost reduction features. Design and manufacture have been accomplished without incurring a large preparation expense or excessive time delay in getting into production.

As soon as World War II ended, intensive crossbar switch development was undertaken to meet the challenge of rapidly rising material and manufacturing costs. Several new designs of switches were investigated but these would all require considerable expenditure of time and money to complete development and to prepare for quantity manufacture. Such factors were of particular significance in view of the persistent heavy demands for telephone service.

As the result of the intensive effort on these new designs, several cost reduction features appeared applicable to the existing switch. These were incorporated in a switch similar in design to that manufactured prior to the war and the new switch has completely superseded the older one. The present annual production rate is about 145,000 switches.

Of the several new features introduced, the most important appear in the vertical unit, illustrated in the headpiece. The differences between the older unit and the new are:

a. The holding magnet coil and core are adjustable as a unit to simplify contact adjustment.

b. The holding magnet core head and its pole face have been designed to facilitate gauging of the armature travel.

c. The contact spring load to be operated by the holding magnet has been reduced, particularly at the operated position of the armature. This was accomplished by decreasing the spring thickness; thus, less raw material is required while improved performance of the vertical unit has been gained.

d. Changes in the mechanical structure of the vertical unit armature and in the construction of the vertical unit frame have been made to simplify manufacture.

e. Molded vertical unit off-normal contact spring assemblies are now used to minimize manufacturing variations and to reduce cost.

f. A new technique of "roll" welding contacts is employed for the front contact multiple.

The original design of the crossbar switch was such that nearly all of the adjustment required occurred in the individual vertical units. The major effort in redesign, consequently, was directed toward reducing this adjustment. Previously, group adjustment of contact springs was impracticable, since the operated position of the armature was fixed by the U-shaped pole piece of the holding magnet (Figure 1), which was welded in place and thus permanently located the pivot edges of the armature. In addition, machining operations on the U-shaped pole piece and on the core face were required, and these have been eliminated in the new

design. Any change in the point of contact closure required adjusting three lugs that support the stationary contact front multiple, and adjusting the individual spring tangs.

In the new design, Figure 2, the holding magnet core can be shifted in a longitudinal direction by as much as 1/32 inch. The core is mounted in a "saddle," bent up from the base, and the core is clamped securely in this saddle by means of a screw. Thus, the operated position of the armature is dependent upon where the core pole face is located.

The new holding magnet core is provided with a head having dual faces. One face, A, is in a plane essentially perpendicular to the center line of the core, but the face, B, is in a plane five degrees out of parallel with face A. The intersection of the two faces is on a line parallel to the armature pivot edge. This facilitates gauging, since the intersection is the highest point on the core pole face. The head of the core is essentially square, when viewed along the longitudinal axis of the core, and is sufficiently large to give the required pulling capability at wide armature airgaps.

To assure interchangeability, the same resistance coil is used on the new holding magnet as that used on the earlier switch. Consequently, the power supplied for operation is the same, and the operating characteristics had to be the same as those of the earlier vertical units. The cost of the postwar holding magnet coil has been drastically reduced through design changes, such as eliminating the non-terminal spoolhead and the vincellatate muslin cover, and by the use of improved manufacturing methods.

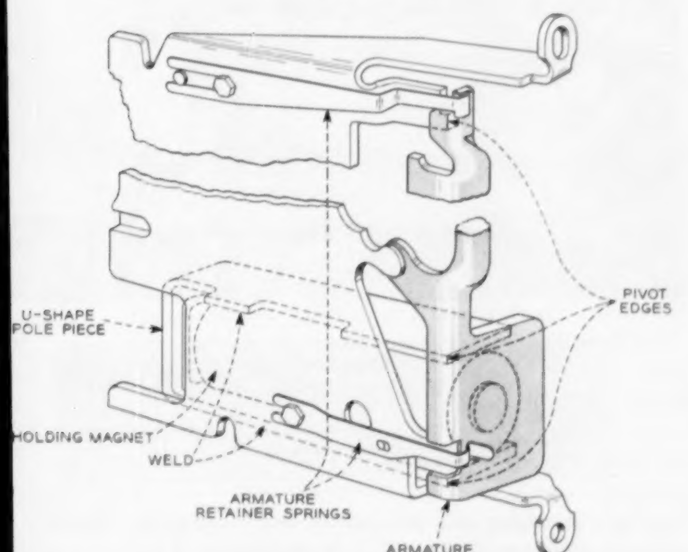


Fig. 1 — The holding magnet of the vertical unit was a "U" shaped structure in which the armature pivoted about the legs of the "U." The core pole face was located permanently a few thousandths of an inch below the pivot edges.

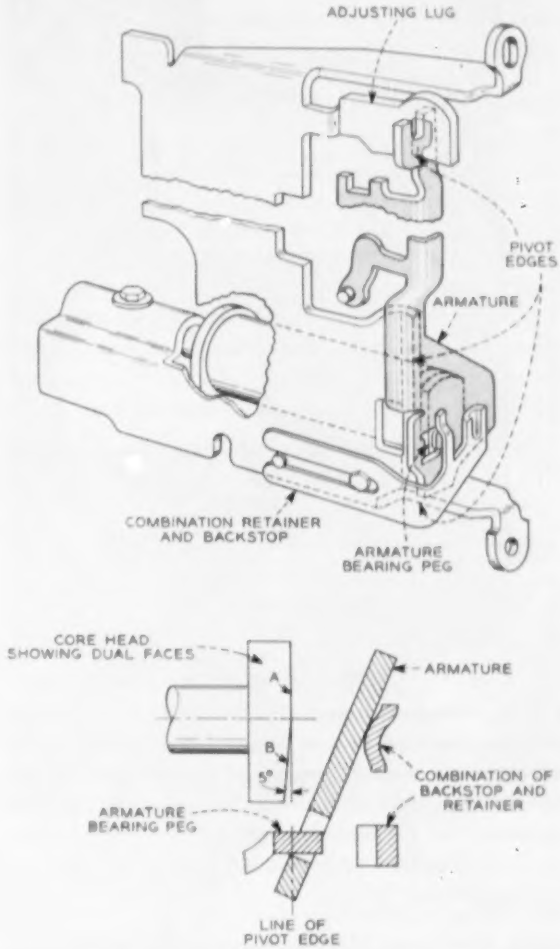


Fig. 2 — The present holding magnet is adjustable longitudinally by means of a slotted hole in the "saddle" mounting. When the core is in the forward position, the armature strikes the inclined pole face surface B; in the retracted core position, the armature strikes the vertical surface A.

Typical pull curves for the old and new structures, illustrated in Figure 3, show that the new magnet has somewhat better pull at wide armature gaps, although slightly less pull near the operated position of the armature. The magnetic reluctance of the new holding magnet in its operated position is higher than that of the older magnet, because of magnetic saturation in the relatively constricted parts of the vertical unit base near the saddle, and

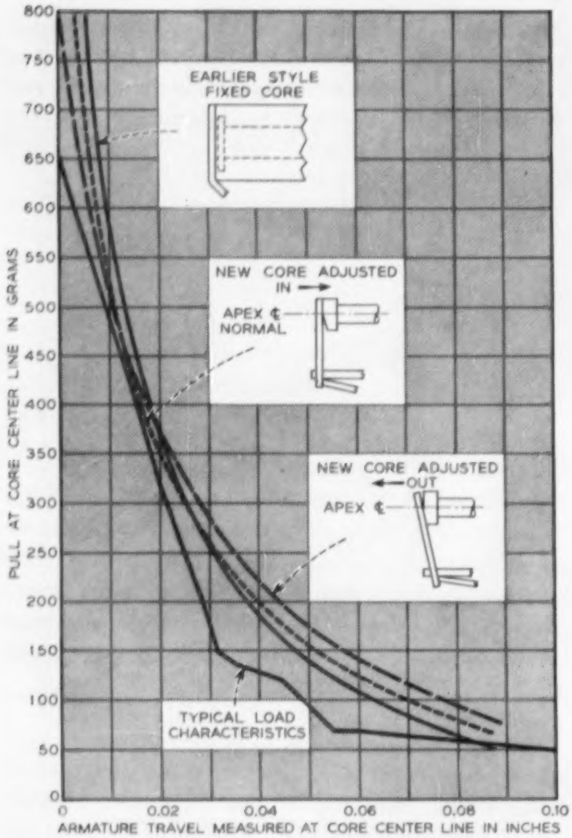


Fig. 3 — Pull and load characteristics of a typical vertical unit. For comparison, the pull of the earlier "U" shaped magnet is shown. To operate the vertical unit, the pull of the magnet must be equal to, or greater than the corresponding load at every position of the armature during the operating stroke.

at the pivot area. The reluctance of the saddle joint itself, however, is small in comparison with that of the rest of the magnetic circuit, even with some degree of misfit between saddle and core that might occur during manufacture.

At wide armature gaps, improved pull of the new holding magnet obtains for all adjusted positions of the core. The point of contact with the armature is so located that, with the core all the way forward, the armature will not "rock" over this point; that is, the armature will not leave the pivot edge when the magnet is energized. Both surfaces of the core pole face are large enough to provide the desired pull at wide gaps.

Since the size of the core pole face influences the rate of flux build-up and its relation to the load to be operated, the core head must be large enough to provide the required pulling characteristics, while at the same time small enough to meet its operate and release times. Two core head sizes have been standardized, one having an area of 0.186 square inch and the other 0.294 square inch.

Another feature of the holding magnet structure is the method of supporting the armature. The older pivot edge bearing has been eliminated in favor of a "peg" type bearing. As shown in Figure 2, the armature pivots on the pole-piece knife edge, which has a "peg" type lug extending through the armature in the bearing, and the armature is held in position by a combination retaining lug and back stop. At the upper armature bearing, the retainer spring formerly used at this point is no longer required; in its place a U-shaped cut-out on the armature fits into an adjusting lug extending from the vertical unit base. Broaching of the armature, a relatively slow operation, has been eliminated.

The crossbar switch was one of the first pieces of telephone apparatus to make extensive use of palladium-capped contacts on bifurcated springs. Over 5,000 individual contacts are provided in a single switch, and these are all readily accessible

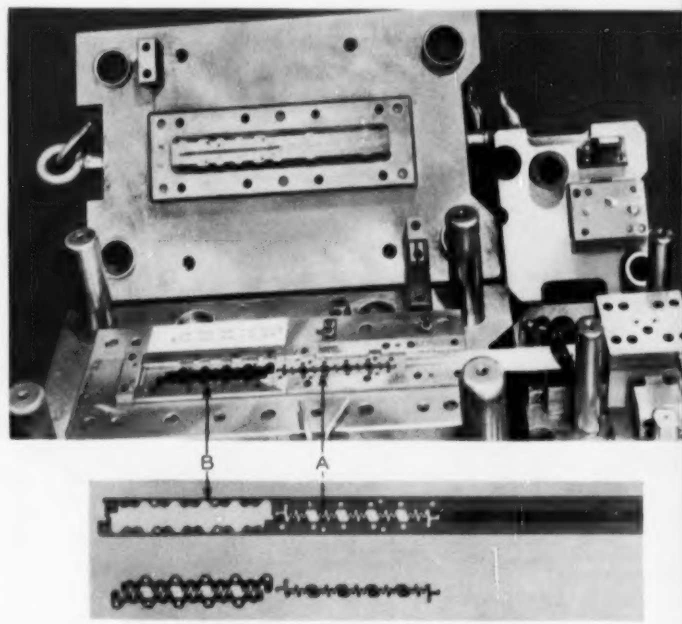


Fig. 4 — Blanking die for roll-welded multiples. (Shown open to illustrate operations.) At position **A**, *the waste section is punched; at position* **B**, *the two finished multiples are punched out and separated. In this way, the contacts are accurately located and, at the same time, the welding is accomplished economically.*

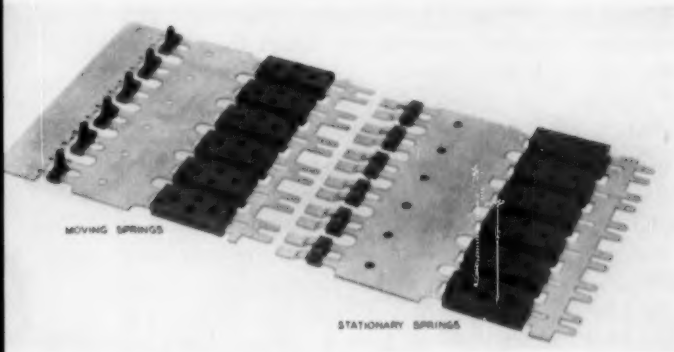


Fig. 5 — Holding off-normal contact springs are partially completed in progressive punching tools and then molded in plastic. After molding, these contact springs are separated by punch press operation.

for inspection and maintenance. Reliability in service provided by this type of contact and manner of circuit selection has been demonstrated by the very infrequent contact troubles that have been encountered in service of the switch for almost twenty years.

Initially, both the fixed and moving contacts on the vertical unit were welded individually on each spring tip. A new method of continuous welding, developed by the Western Electric Company, has been adopted for the stationary contacts located on the front multiples. This is called "roll welding," in which the parts to be welded are fed together between two revolving wheel-shaped electrodes electrically controlled to produce substantially a continuous weld.

The configuration of these parts is such that a pair of multiples can be punched from a flat strip which has already had the contact material roll welded onto it. As illustrated in Figure 4, the multiples are punched in pairs, then separated, and the unused precious metal salvaged from the waste section. In this way, the contacts are accurately located and the welding is accomplished economically. Contacts on the moving springs and on the off-normal spring are welded in place by conventional methods, since they do not lend themselves to this roll welding technique.

By a new "punch and mold technique" (Figures 5 and 7), a number of off-normal contact spring parts are partially completed in progressive punching tools and then molded in thermosetting plastic before completing the punching of the spring parts into separate spring assembly pairs. A pair of spring parts are held together by molded compound (Figure 7). This makes it unnecessary to handle separate parts in assembling off-normal contact springs, and the complete off-normal assembly is made by using one of each kind of spring pairs, along with a balancing spring, and riveting these to a mounting bracket.

Adjustment of the new vertical units is now relatively simple since they are assembled in fixtures with gauges inserted as required. Consequently, the units meet practically all requirements without adjustment; those few requirements which are not met in this way, can easily be adjusted for by simply bending lugs and adjusting spring tangs.

A more recent addition to the vertical unit armature to enhance the speed of operation of the switch, consists of five damping "cones." When a circuit through a switch is disconnected, a selecting finger that has been held operated by a vertical unit armature is suddenly released. The finger will then vibrate at least once into the opposite "trapping" zone (Figure 6), whereby, if the same holding magnet were to be re-energized immediately, a false connection could result.

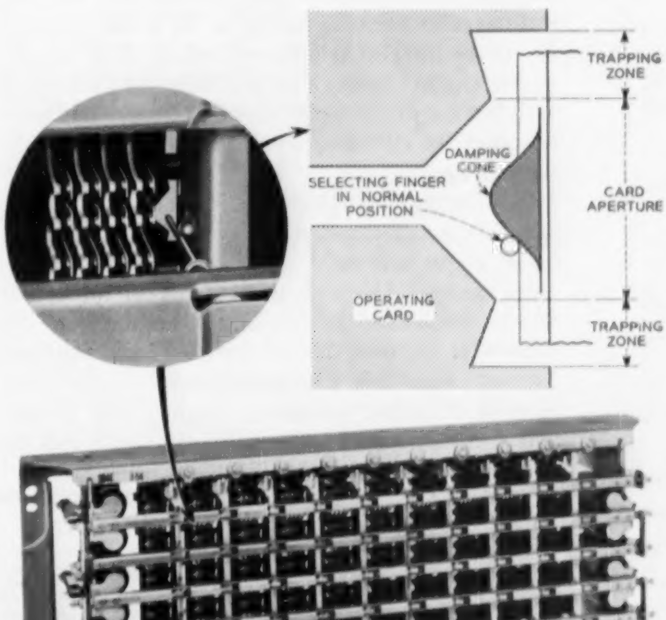


Fig. 6 — When a selecting finger is released, the damping cone on the armature prevents the finger from vibrating into the opposite "trapping zone."

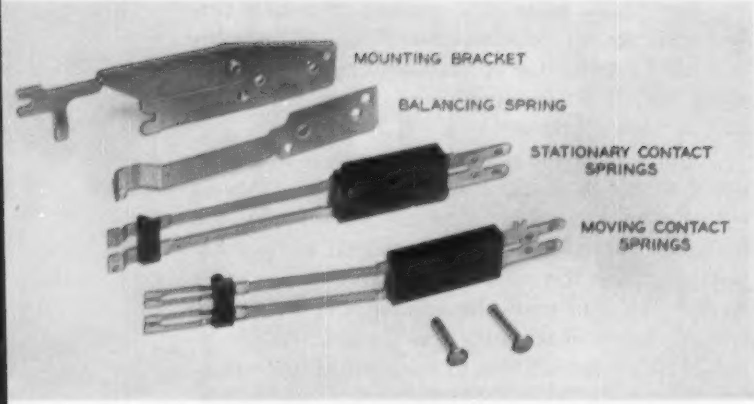


Fig. 7 — Exploded view showing the various components of a holding off-normal contact spring assembly.

Heretofore, an appreciable circuit delay interval has been required between the release of a selecting finger and a subsequent re-selection of a crosspoint. With the damping cone, however, the released selecting finger will strike the cone and bounce about the card apertures without entering the trapping zone. A saving of 15 milliseconds in the delay interval is attained, which is of considerable circuit value. The armatures of five coded switches are so equipped, and this feature has been specified for all codes when manufacturing conditions permit.

In addition to design changes on the vertical units, selecting magnets on the new switch have been made about one-third shorter than those of the older design. Although the number of turns that can be wound on the shorter coil for the same resistance is less than that on the long coil, improved magnetic capability is achieved because of the lower reluctance of the magnetic circuit. The shorter coils are cheaper to make, since more coils can be wound at one time. The operating time of the new selecting magnet is also slightly faster than that of the older selecting magnet.

Introduction of the short selecting magnet has made possible further economy in the design of the switch frame. The frame has been simplified by a newly designed upright member replacing two uprights at each end, and by using spot welding at strategic locations instead of the previously used arc welds. Calculations and strain tests have shown the new frame to be equivalent to the old frame in rigidity. This is essential because office frames are handled after switch adjustment, and if any warping of the frame takes place, there is danger that the adjustment of the many individual crosspoint contacts may be impaired. Crossbar switch frames are mounted with a 3-point support to aid in reducing warping. It has been possible to provide additional mounting holes in the crossbar switch frame so that the switch can be mounted on any of the several central office frames which have various mounting hole spacings.

Because many parts used on the older switch have been retained, it has been possible to make use of better materials and improved manufacturing processes without further redesigning. For example, aluminum front multiple spacers are used instead of brass; improvements have been made in the manufacture of the contact spring assemblies, and a more efficient method of soldering the strap wires on the vertical units is used. In addition, the ability to adjust rapidly and adequately during assembly permits the use of wider tolerances on piece-parts than would be possible if adjustment could not be used. Full advantage, too, has been taken of the multiple punch press techniques that have been developed at the Western Electric Company.

After several years' experience elsewhere in the engineering field, C. C. Barber became associated with the Bell System in 1916, when he entered the Panel Apparatus Drafting Department at West Street. In 1918, he became supervisor of that department, and in 1920 transferred to the panel apparatus design group. A number of his ideas became the subject of panel apparatus patents. In 1930, he was put in charge of a group of engineers designing panel and crossbar apparatus. During World War II, he supervised the development of the retracting and hoist-tilt mechanisms of Sonar equipment for the U.S. Navy. Following the war, he returned to supervision of crossbar switch design groups, and, more recently, the supervision of the group handling design, development, and engineering of switchboard components, including the new wire-spring key development, printed wiring connectors, and electron tube sockets.

Dr. Kelly Addresses National Industrial Research Conference

"Through solid state electronics made possible by profitable research, a most challenging and rewarding future lies ahead for telephone technology," Dr. M. J. Kelly declared in a recent address reviewing accomplishments of the Laboratories. The talk entitled, *The Record of Profitable Research at Bell Telephone Laboratories,* was delivered at the National Industrial Research Conference held in Chicago, April 18, under the sponsorship of the Armour Research Foundation of the Illinois Institute of Technology.

Dr. Kelly said, in part: "Bell Telephone Laboratories, one of the nation's largest research establishments performs research in the physical sciences in all areas that might be expected to provide new knowledge for communications technology. Based on the knowledge acquired, it develops the technical facilities that the Bell System employs in providing communications services to the nation. While telephony is the principal service provided, in recent years many other services have been supplied such as radio and television program distribution and record and data transmission. Since 1938 the Laboratories has also performed large service in research and the development of communications and weapon systems for the Department of Defense.

Dr. M. J. Kelly addresses first National Industrial Research Conference in Chicago.

"Research to increase the range of telephony, to improve the quality of the transmitted speech and to lower costs of transmission has been an important and continuing area of effort. Today any one of the nation's 54 million telephone customers can reach not only every other one of its customers but almost 93 per cent of the 38 million telephones of the rest of the world. Telephony has become global.

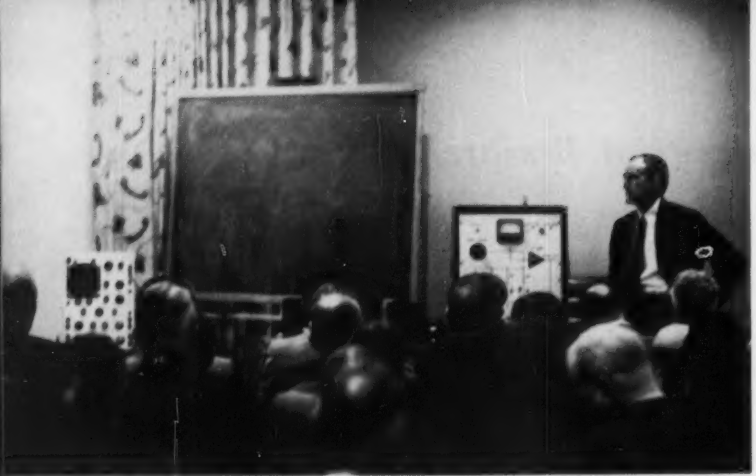
"Another important area of research is the telephone station set. It is the most familiar item of telephone equipment to the general public. On a typical day, users of Bell System service complete some 170 million calls originating at these sets that go through the system's exchanges and many million more that are completed within the private branch exchanges of business, industry and government. Forty-six million sets are employed in this service. For growth and replacement, the Western Electric Company produces some five million sets in a year.

"The interconnection of the called and calling parties is also an essential element of telephone service. In the first 30 years of telephony, almost all interconnection was performed manually. In 1920, the first automatic interconnection means, a product of our Laboratories research, went into service. The proportion of automatic interconnection has steadily increased since then until now some 87 per cent of the telephone customers dial their own service area calls.

"A relatively new research program at the Laboratories has been directed toward the use of matter in the solid state for electronic implementation of telephone service. Semiconductors, dielectric, ferroelectric and ferromagnetic materials have all been subjected to our research attack. Out of each of these areas have come new electronic components that will play their part in providing completely new instrumentation for telephony.

"New solid state electronic systems will make their impact during the next few decades. This impact will be proved evolution and not revolution. A fifteen billion dollar, long-lived plant will not disappear over night. Its retirement, however, will be hastened and all growth plant will be instrumented by solid state electronics."

On April 20, Dr. Kelly also spoke at the celebration of the Fiftieth Anniversary of Cooperative Education held at the University of Cincinnati. The subject of this talk was *The Call of Science and Engineering.*



Bell System Chief Engineers Visit Chester Field Laboratory

Dr. J. B. Fisk, Laboratories Executive Vice President, addressed Bell System Chief Engineers at Whippany before the trip to the Chester Field Laboratory.

An outside plant demonstration and exhibit was held at the Chester Field Laboratory on March 21 as part of a conference for Bell System Chief Engineers. One hundred fifteen conferees from twenty-two Bell System companies attended this conference sponsored by the A.T.&T. Company.

During the morning of March 21, the Chief Engineers attended several talks at the Whippany Laboratory including an introduction by Dr. J. B. Fisk; a talk on *Bell System Data Processing* by J. H. Felker; *Pulse Code Modulation Carrier* by E. E. Sumner; and *Electronic PBX's* by E. I. Green. Following lunch at Whippany, the conference members went by bus to the Chester Field Laboratory.

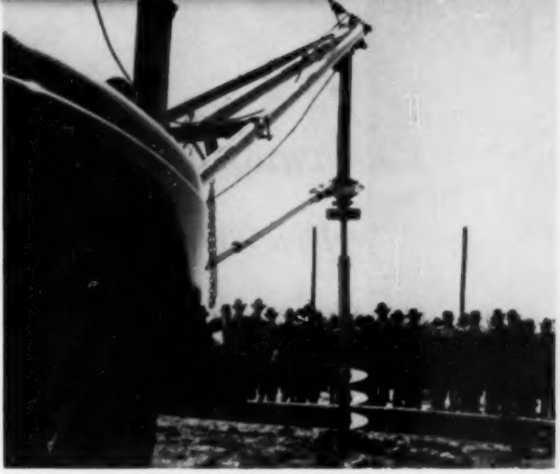
The demonstrations at Chester had originally been scheduled for March 20, but the heaviest snowfall of the season on March 19 made it necessary to delay the program until the following day. As a result of this storm, everyone concerned with the demonstrations spent March 20 removing enough snow with shovels, plows, and bulldozers to hold the program on the following day. (Ninety-nine pairs of overshoes were distributed at Chester for use by conference members.)

General coordinator of the Chester demonstrations was S. A. Haviland of the A.T.&T. Company, and Laboratories expeditor was C. C. Lawson. Others who took part in arranging the program and manning the exhibits included: J. G. Mann, J. MacDougall, K. C. MacLean, C. S. Basinger, F. C. Buerk, A. Paone, B. Snow, W. Methven, C. N. Smith, J. T. O'Connell, R. T. Hermann, W. J. Boudreau, E. J. Bonnesen, and E. W. Glancy, all of the A.T.&T. Company.

J. G. Sullivan of New Jersey Bell and a number of members of the Laboratories also played an important part in the program. The latter included: S. M. Sutton, R. G. Watling, K. J. Dahms, E. L. Alford, D. C. Smith, and R. B. Ramsey, in addition to the regular Chester staff.

Bell System Operating Companies supplying equipment and crews included, New Jersey, Chesa-

Left — Caterpillar tractor, cable plow unit, and hydraulic cable reel trailer used in laying underground cable. Right — Pole platforms and equipment for splicing aerial cable were demonstrated at Chester. Lineman is B. Crowder of the Chesapeake and Potomac Company.



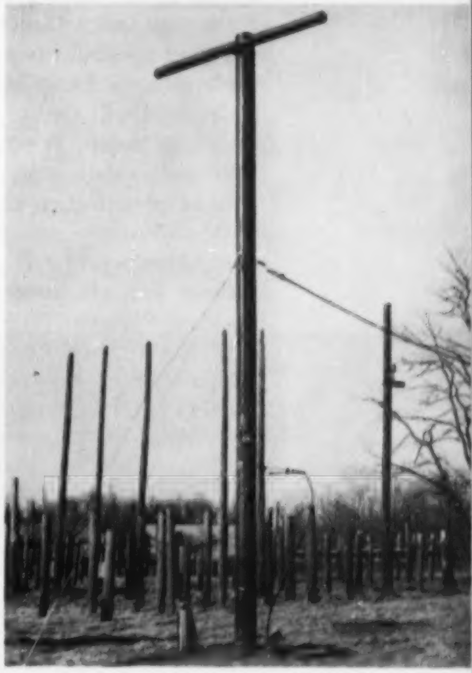
Left — Conference members observed front-mounted hydraulic pole-hole digger in operation. Right — Cable terminals and cable terminal housings (left), and trenchers for burying distribution cable (right) were exhibited at Chester. Operator is T. W. Rolph of the Laboratories.

peake and Potomac-Washington, Pennsylvania-Eastern, Indiana, Southern New England, Southwestern, and New York-Long Island.

During the course of the program at the Chester Laboratory a buried-plant demonstration was held to illustrate some of the plowing and trenching equipment used in the field today, and new equipment that is expected to be available in the near future. Also, a line-truck derrick and digger demonstration illustrated the use of front- and rear-mounted hydraulic pole derricks, and hydraulic and mechanical pole-hole diggers.

General exhibits at Chester included: conduit materials and new developments, aerial cable splicing equipment, Fiberglas poles, work area safeguards, one-man splicing equipment, tower-ladder safety devices, and other outside plant tools and materials.

The program was later repeated for two groups of visitors including A.T.&T., Laboratories and Operating Company outside-plant engineers.



Fiberglas telephone poles are being tested extensively at Chester for possible Bell System use.

Left — Members of the conference examined an improved aerial tent (center), and new ladders and ladder safety equipment (left). Demonstrators are, from left to right: K. C. MacLean, A.T.&T.; J. D. Apgar, K. J. Dahms, BTL; and W. Methven, A.T.&T. Right — E. J. Bonnesen of the A.T.&T. Co. (on truck) described safety devices for crews working in and around manholes to conference members.

H. V. Schmidt

W. E. Burke

A. P. Lancaster

Three New Western Electric Vice Presidents

H. V. Schmidt, A. P. Lancaster, and W. E. Burke were recently elected Vice Presidents of the Western Electric Company.

In anticipation of the July 1 retirement of H. C. Beal, Vice President-Manufacturing and a Director of Western and a Director of the Laboratories, the following assignments and reassignments at Western became effective May 1:

Mr. Beal will devote his time to activities of a consulting nature in connection with the reassignment and realignment of responsibilities involved in these organization changes. A. B. Goetze, Vice President-Finance, succeeded Mr. Beal as Vice President-Manufacturing. P. A. Gorman, Vice President-Defense Projects, succeeded Mr. Goetze as Vice President-Finance. W. E. Burke, Project Manager-572 (DEW Line), Defense Projects Division, succeeded Mr. Gorman as Vice President-Defense Projects and in this capacity reports to F. R. Lack, Vice President-Radio Division.

T. E. Shea, Vice President-Manufacturing, Eastern Area, is appointed Vice President-Personnel and Public Relations, a new position reporting to the President, with the Personnel Director and the Director of Public Relations reporting to him. Mr. Shea is a former Vice President of the Laboratories. A. P. Lancaster, Works Manager-Kearney Works, succeeded Mr. Shea as Vice President-Manufacturing, Eastern Area. H. V. Schmidt, Engineer of Manufacture, was named Vice President-Chief Engineer, a new position reporting to the President and responsible for the Company-wide engineering and technical interests of the business. H. S. Snell, Assistant Works Manager-Indianapolis Works, was appointed Engineer of Manufacture at Headquarters succeeding Mr. Schmidt.

H. V. Schmidt joined the Western Electric Company in 1917 at its Hawthorne Works in Chicago after attending Iowa State College. A. P. Lancaster graduated from Texas A & M College in 1922 with an E.E. degree and then joined Western Electric.

W. E. Burke graduated from Oregon State College with a B.S. degree in electrical engineering. He joined Bell Telephone Laboratories in 1928 and later transferred to the Western Electric Company.

H. K. Onstott Joins A.T.&T.

H. K. Onstott, Laboratories Assistant Vice President in charge of General Staff, resigned effective May 1, 1956, to accept a position as Assistant Vice President in the Personnel Relations Department of the American Telephone and Telegraph Company. He succeeds G. S. Dring who retired on that date.

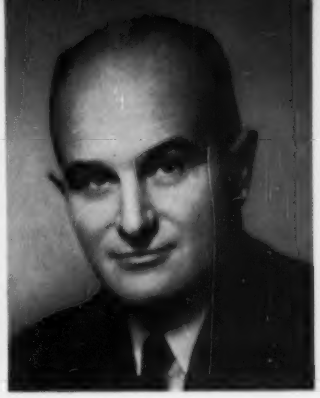
Mr. Onstott has been with the Bell System since he graduated from Cornell University in 1924 with an A. B. degree in economics. Prior to his appointment as Assistant Vice President of the Laboratories in May, 1952, he was Eastern Distribution Manager for the Western Electric Company.

H. K. Onstott

H. J. Wallis, formerly New York Area Manager, succeeded Mr. Onstott as Assistant Vice President of the Laboratories. Mr. Wallis was General Service Manager at Murray Hill and Superintendent of Development Staff Services at Sandia before becoming New York Area Manager in 1953.

New Presidents Elected by New England and Michigan Bell Companies

W. M. Day



E. N. White

William M. Day has been elected president of the Michigan Bell Telephone Company to succeed Clifton W. Phalen, now an A.T.&T. Co. Executive Vice President, and Erskine N. White has been elected President of the New England Company.

Mr. Day, a Yale graduate, began his telephone career with the New York Telephone Company in 1928 and went to the Information Department (now Public Relations) of A.T.&T. in 1936. He spent a number of years with the A.T.&T. Information Department, and was on leave of absence for four years during World War II. He went to the Michigan company as Vice President, Public Relations, in 1948. Mr. Day later was named Vice President and General Manager.

Mr. White joined the Bell System in 1923 with A.T.&T., and went to the New England company six years later. He became Vice President in charge of Operations in 1950, after serving as Public Relations Director; Vice President, Public Relations and Personnel; Vice President and General Manager, and Vice President, Rate and Revenue Requirements, all in the New England Company.

Mr. White succeeds Joe E. Harrell, who now is chairman of the board. Mr. Harrell will retire later this year.

The portrait accompanying the biography of R. E. Anderson, author of an article entitled "The A2A Video Transmission System" published in the April, 1956, issue of the Record, was inadvertently replaced by a portrait of G. T. Anderson. The Record apologizes for this error and is pleased to publish R. E. Anderson's portrait at the left.

Members of Laboratories Participate in I.R.E. National Convention

The Laboratories was represented by twelve members at the National Convention of the Institute of Radio Engineers held at the Waldorf-Astoria Hotel and the Kingsbridge Armory in New York City from March 19 through March 22.

Three technical sessions at this convention were directed by members of the laboratories: the session on Automatic Control was directed by J. C. Lozier; Over the Horizon Systems by K. Bullington; and Circuits II – Design and Application of Active Networks by W. R. Bennett. The Laboratories was also represented by papers in a number of other sessions including the following: General Communications Systems, Ultrasonics, Circuits I, Information Theory II, Solid State Devices, Information Theory III, and Microwave Instrumentation.

E. E. David of the Laboratories delivers a paper to the Information III session of the I.R.E. National Convention. E. H. Kretzmer, Laboratories author of the preceding paper, is seated at the far left.

Titles and authors of papers delivered at these sessions are listed under Talks on page 199.

Laboratories to Offer Training Program for Operating Telephone Company Engineers

The Laboratories will begin a two year training program in "new art" technology for operating company engineers this fall. Forty trainees will be selected each year. This program, which is the result of a recommendation by a committee of operating company representatives, will consist of both formal class work and rotational work assignments in new-art areas.

Policy guidance will be given the program by a technical department committee consisting of W. A. MacNair, chairman, and A. J. Busch, M. B. McDavitt, B. McMillan, J. A. Morton, R. J. Nossaman, and S. B. Ingram, secretary. J. N. Shive, formerly of the Solid State Device Department, will be responsible for coordinating matters pertaining to the text material and the presentation of the courses.

The program will have two broad objectives: first, operating company engineers will be trained so that they may have a basic working understanding of new-art areas including electronic switching systems and data processing systems. Secondly, the program aims to aid in the development in the operating companies of a group of engineers who can assume technical leadership in the introduction of new-art techniques in the Bell System.

Operating companies will send representatives to the Laboratories. The trainees will be younger engineers of high technical potential and Bell System experience who show initiative and originality in their approach to the solution of telephone problems of an unusual nature. About one-third of the total time will be used for class work and study in seven scheduled courses, and two-thirds for rotational assignments. Emphasis in all courses will be on the physical understanding of the phenomena involved.

Courses include Solid State Devices, Switching Tubes, Electronic Circuits, Basic Functions of Electronic Switching Systems, Computers and Data Handling Technology, and Systems Engineering. Rotational assignments will be in the corresponding development and engineering areas.

Papers Published by Members of the Laboratories

Following is a list of the authors, titles, and place of publication of recent papers published by members of the Laboratories

Abbott, L. E., and Pomeroy, A. F., *How to Get More Range From An Air Gage*, Am. Machinist, 100, pp. 113-115, Feb. 27, 1956.

Becker, J. A., and Brandes, R. G., *A Favorable Condition for Seeing Simple Molecules in a Field Emission Microscope*, J. Appl. Phys., 27, pp. 221-223, Mar., 1956.

Bennett, W. R., *Characteristics and Origins of Noise – Part I.*, Electronics, 29, pp. 154-160, Mar., 1956.

Blecher, F. H., *A Junction Transistor Integrator*, Proc. National Electronics Conference, 11, pp. 415-430, Mar. 1, 1956.

Brady, G. W., *X-Ray Study of Tellurium Oxide Gas*, J. Chem. Phys., Letter to the Editor, 24, p. 477, Feb., 1956.

Brandes, R. G., see Becker, J. A.

Brattain, W. H., see Garrett, C. G. B.

Braun, F. A., *Mounting Scheme for Large Cathodes*, Rev. Sci. Instr., Lab. and Shop Notes Section, 27, p. 113, Feb., 1956.

Eigler, J. H., see Sullivan, M. V.

Fox, A. G., *Wave Coupling by Warped Normal Modes*, I.R.E. Trans., PGMTT, 3, pp. 2-6, Dec., 1955.

Garrett, C. G. B., and Brattain, W. H., *Some Experiments on and a Theory of Surface Breakdown*, J. Appl. Phys., 27, pp. 299-306, Mar., 1956.

Herrmann, D. B., see Williams, J. C.

Kelly, M. J., *Contributions of Research to Telephony – A Look at the Past and a Glance into the Future*, Franklin Inst., J., 261, pp. 189-200, Feb., 1956.

Logan, R. A., *Thermally Induced Acceptors in Germanium*, Phys. Rev., 101, pp. 1455-1459, Mar. 1, 1956.

Mason, W. P., *Comments on Weertman's Dislocation Relaxation Mechanism*, Phys. Rev., Letter to the Editor, 101, p. 1430, Feb. 15, 1956.

Pomeroy, A. F., see Abbott, L. E.

Robertson, S. D., *Ultra-Bandwidth Finline Coupler*, I.R.E. Trans., PGMTT, 3, pp. 45-48, Dec., 1955.

Rose, D. J., *On the Magnification and Resolution of the Field Emission Electron Microscope*, J. Appl. Phys., 27, pp. 215-220, Mar., 1956.

Suhl, H., *Subsidiary Absorption Peaks in Ferromagnetic Resonance at High Signal Levels*, Phys. Rev., Letter to the Editor, 101, pp. 1437-8, Feb. 15, 1956.

Sullivan, M. V., and Eigler, J. H., *Electrolytic Stream Etching of Germanium*, J. Electrochem. Soc., 103, pp. 132-134, Feb., 1956.

Trent, R. L., *Design Principles of Junction Transistor Audio Amplifiers*, I.R.E. Trans., PQA, 3, pp. 143-161, Sept.-Oct., 1955.

Van Uitert, L. G., *High Resistivity Nickel Ferrites – The Effects of Minor Additions of Manganese or Cobalt*, J. Chem. Phys., 24, p. 306, Feb., 1956.

Williams, J. C., and Herrmann, D. B., *Surface Resistivity of Nonporous Ceramic and Organic Insulating Materials at High Humidity with Observations of Associated Silver Migration*, I.R.E. Trans., PGRQC, 6, pp. 11-20, Feb., 1956.

Wolontis, V. M., *A Complete Floating-Decimal Interpretive System for the IBM 650 Magnetic Drum Calculator*, IBM Technical Newsletter, 11, Mar., 1956.

Talks by Members of the Laboratories

During March, a number of Laboratories people gave talks before professional and educational groups. Following is a list of speakers, titles, and places of presentation.

American Physical Society Meeting, Pittsburgh, Pa.

Benson, K. E., see Goss, A. J.

Bond, W. L., *Imperfections in Almost Perfect Silicon.*

Bond, W. L., see McSkimin, H. J.

Boothby, O. L. see Williams, H. J.

Dillon, J. F., Jr., *Ferromagnetic Resonance in Thin Discs of Manganese Ferrite.*

Feher, G., and Fletcher, R. C., *Relaxation Effects in Donor Spin Resonance Experiments in Silicon.*

Feher, G., see Fletcher, R. C.

Fletcher R. C., and Feher, G., *Electron Spin Resonance in Heat Treated Silicon.*

Fletcher, R. C., see Feher, G.

Geballe, T. H., see Herring, C.

Goss, A. J., Benson, K. E., and Pfann, W. G. *Dislocations at Compositional Fluctuations in Germanium-Silicon Alloys* (presented by G. L. Pearson).

Herring, C. and Geballe, T. H., *Thermomagnetic Effects in Germanium.*

Hrostowski, H. J., see McSkimin, H. J.

Lax, M., *Giant Traps.*

Lewis, H. W., *The Role of the Uncertainty Principle in Conductivity Theory.*

McSkimin, H. J., Bond, W. L., Pearson, G. L., and Hrostowski, H. J., *Elastic Constants of InSb and GaSb Single Crystals.*

Pearson, G. L., see Goss, A. J.

Pearson, G. L., see McSkimin, H. J.

Pfann, W. G., see Goss, A. J.

Prince, E., *Crystal Structure of Two Tetragonal Pseudo-Spinels.*

Sherwood, R. C., see Williams, H. J.

Suhl, H., *Ferromagnetic Absorption at High Microwave Signal Levels.*

Walker, L. R., *Resonant Modes of Ferromagnetic Spheroids.*

Wertheim, G. K., *Observation of Short Carrier Lifetimes.*

Williams, H. J., Sherwood, R. C., and Boothby, O. L., *Magnetostriction and Magnetic Anisotropy Constant of MnBi.*

I.R.E. National Convention, New York City.

Clark, M. A., *Optimum Design of Power Output Transistors.*

David, E. E., Jr., and McDonald, H. S., *A Bit-Squeezing Technique Applied to Speech Signals.*

Faving, D. L., *A Swept, Broadband Microwave Double Detection System with Atomatic Synchronization.*

Graham, R. E., *Modulated Control Systems.*

Koerner, L. F., *Methods of Reducing Frequency Variations in Crystals Over A Wide Temperature Range.*

Kretzmer, E. R., *Reduced-Alphabet Representation of Television Signals.*

McDonald, H. W., see David, E. E., Jr.

McLean, D. A., and Power, Mrs. F. S., *Tantalum Solid Electrolytic Capacitors.*

Meitzler, A. H., *Propagation of Elastic Pulses Near the Stressed End of a Cylindrical Bar.*

Power, Mrs. F. S., see McLean, D. A.

Other Talks

Arnold, S. M., *Metal Whiskers, Their Growth and Properties,* International Nickel Company Research Laboratories, Bayonne, N. J.

Baker, W. O., *Polymer Carbon,* Akron Polymer Lecture Group, University of Akron, Ohio; and *Reciprocity of Chemistry and Physics of the Solid State,* Sigma Xi, New York University, New York City.

Beach, A. L., see Kern, H. E.

Caldwell, C. W., Jr., see Kern, H. E.

Chapin, D. M., *The Bell Solar Battery,* Millburn High School science students, N. J.

Ciccolella, D. F., *The Bell Solar Battery,* Newark Mineralogical Society, Newark Museum, N. J.; and *Diffused Junction Silicon Rectifiers and Voltage Limiters,* I.R.E., Piedmont Subsection, Burlington, N. C.

Compton, K. G., *Potentials as the Criteria for Cathodic Protection of Underground Lead Cable Sheath,* National Association of Corrosion Engineers, Symposium on Corrosion in Communications and Power Industry, New York City.

Denton, R. T., *The High-Frequency Diffused Base Germanium Transistor,* Pennsylvania State University, University Park, Pa.

Donahue, A. H., *The Rural PI Carrier System – Systems Engineering,* University of Illinois, Urbana.

Ebers, J. J., *Avalanche Breakdown in Semiconductors,* Physics Colloquium, Wayne University, Detroit, Mich.

Felker, J. H., *The Modern Digital Computer – An Outlet for Technological Creativity,* Eta Kappa Nu Spring Meeting, Cornell University, Ithaca, N. Y.

Ferrell, E. B., *Number Systems,* Columbia University, Annual Meeting of New York Association of Mathematics Teachers, New York City (presented by P. B. Myers).

Finch, T. R., *Transistor Circuits for Computer Application,* I.R.E., Detroit Section and Student Section, University of Michigan, Ann Arbor.

Foster, F. G., *Microscopy in Engineering,* Research and Development Flight, 9255th Air Reserve Squadron, Drew University, Madison, N. J.

Gnaedinger, R. J., *Semiconductor Developments,* New York Telephone and Telegraph Company, New York City.

Talks by Members of the Laboratories, Continued

Herring, C., *Thermoelectricity and Thermal Conduction in Semiconductors,* Physics Colloquium, University of Pittsburgh.

Hobstetter, J. N., *Dislocations in Metals,* Maryland Institute of Metals, Baltimore.

Hutson, A. R., *The Measurement of Thermoelectric Power of Small Semiconductive Crystals,* Conference on Physical Electronics, Massachusetts Institute of Technology, Boston.

Kaplan, E. L., *Statistical Inference and Decision Theory Applied to Submarine Cable Reliability,* Statistics Department Seminar, Johns Hopkins University, Baltimore, Md.

Karlin, J. E., *User Preference Research in Engineering,* Michigan Bell Telephone Company, Board of Directors Meeting, Detroit.

Kern, H. E., Caldwell, C. W., Jr., Beach, A. L., and Stratton, W. D., *Gas Content of Carbonized Nickel as a Function of Base Nickel Purity – Correlation of Tube Life with Anode Gas Content,* Physical Electronics Conference, Massachusetts Institute of Technology, Cambridge, Mass.

Kohman, G. T., *The Growth of Piezoelectric Crystals,* American Chemical Society, South Jersey Section, Penns Grove, N. J.

Kuh, E. S., *Network Synthesis Using Potential Analog,* Columbia University, New York City.

Mack, J. E., *Pulse Switching Characteristics of Magnetic Cores,* Lehigh University, Physics Department Colloquium, Bethlehem, Pa.

Maddox, H. D., *Bell Telephone Laboratories Organization for Control of Air Force Projects at North Carolina Works of Western Electric Company,* Western Electric Field Engineering Force – Air Force Conference, Wichita, Kansas.

Mealy, G. H., *Deterministic and Probabilistic Prediction – Their Relation to the Theory of Automata,* Seminar on Discrete Sequence Transducers, Columbia University, New York City.

Moore, G. E., *The Dissociation of Solid Compounds by Electron Bombardment,* Massachusetts Institute of Technology, Physical Electronics Conference, Boston, Mass.

Myers, P. B., see Ferrell, E. B.

Pearson, G. L., *The Silicon p-n Junction Solar Energy Converter,* Optical Society of America and American Chemical Society Joint Meeting, Rochester, N. Y.; and Gulf Research and Development Company, Pittsburgh, Pa.

Perkins, E. H., *The Bell Telephone Laboratories' Place in the Bell System;* and *The P1 Carrier System as a Current Development Project,* HQ 9224th Air Force Reserve Squadron, Lawrence, Mass.

Pfann, W. G., *Zone-Melting as an Engineering Tool,* Chemical Engineering Department Seminar, Princeton University, Princeton, N. J.; and *Recent Developments in Zone-Melting,* Physics and Applied Physics Colloquium, Harvard University, Cambridge, Mass.

Prince, M. B., *New Developments in Semiconductor Devices,* A.I.E.E. Susquehanna Section, Lebanon, Pa.

Schwenker, J. E., *A Terminal for Data Transmission Over Telephone Circuits,* I.R.E., Professional Group on Electronic Computers, New York City.

Shackleton, S. P., *Need and Opportunities for Scientific Personnel in Industry,* Vocational Advisory Service, Spring Institute, Remington Rand Auditorium, New York City.

Sobel, M., *Sample Size Required for Various Statistical Problems in Reliability Studies,* Mathematics Department Seminar, Lehigh University, Bethlehem, Pa.

Stansbury, E. J., *Transistor Physics,* Physics Seminar, McMaster University, Hamilton, Ontario, Canada.

Stratton, W. D., see Kern, H. E.

Sullivan, M. V., *The Bell Solar Battery,* American Chemical Society, Sabine Area Section A.I.Ch.E. and Texas-Louisiana Gulf Section Joint Technical Meeting, Beaumont, Texas.

Thayer, P. H., Jr., *NIKE I: A Guided Missile System for AA Defense,* Harvard Engineering Society, Harvard University, Cambridge, Mass.

Tryon, J. G., *TRADIC: A Transistor Digital Computer,* Electronic Company 3-36, U. S. Naval Reserve, New York City.

Wadlow, H. V., *Application of Methods of Inorganic Analysis,* American Chemical Society, North Jersey Section, Passaic Valley Lecture Series, Nutley, N. J.

Patents Issued to Members of the Laboratories During February

Baker, W. O., and Grisdale, R. O. – *Abrasive Devices* – 2,736,642.

Bond, W. L. – *Technique and Apparatus for Making Crystal Spheres* – 2,734,317.

Goss, F. A., Jr. – *Electrical Control* – 2,734,975.

Grisdale, R. O., see Baker, W. O.

Hanson, R. L., and Kock, W. E. – *Distant-Talking Telephone System* – 2,736,771.

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